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UGANDA AND
ZANZIBAR

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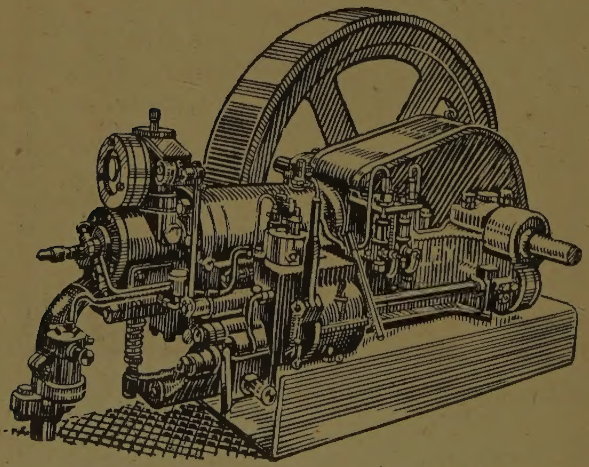

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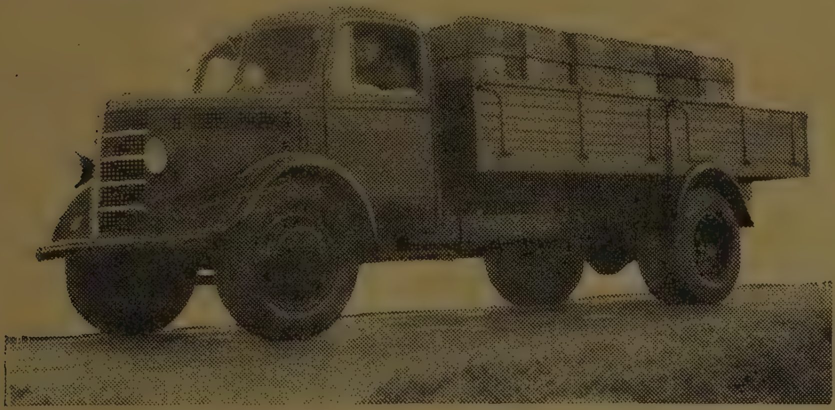

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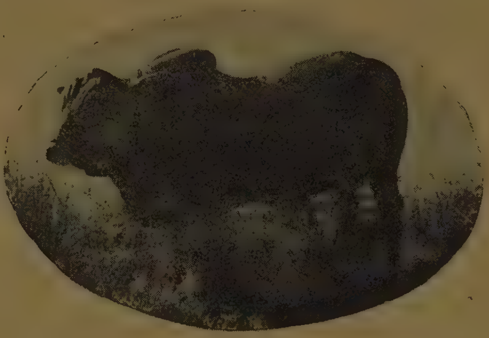

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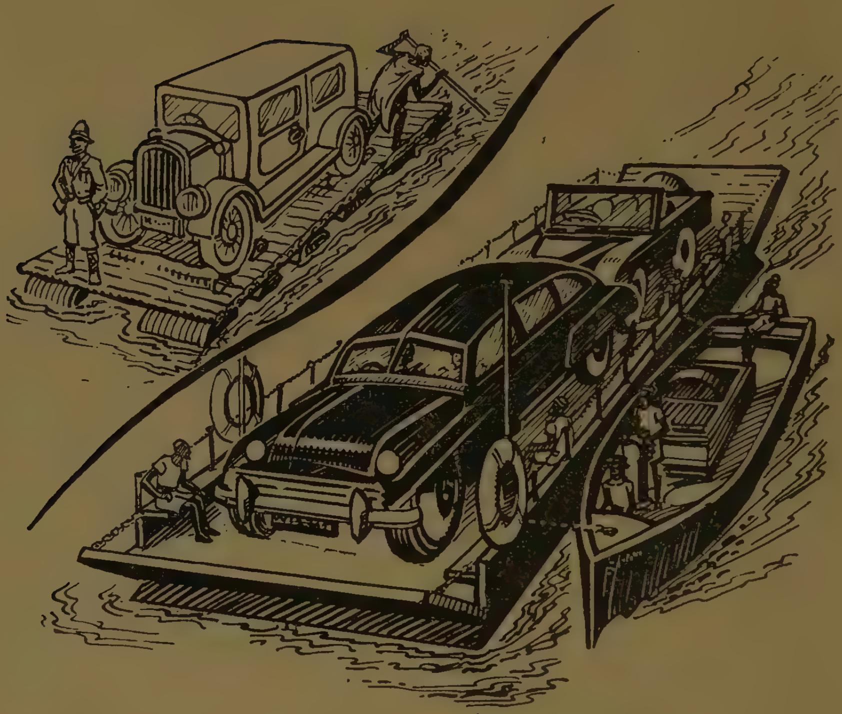

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Readers are reminded that all agricultural inquiries, whether they relate to articles in the Journal or not, should be addressed to the local Director of Agriculture, and not to the Editor.

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ENVIRONMENT AND RESEARCH

A recent publication by Dr. W. S. Ladell* reopens the question of the health of Europeans in tropical and subtropical climates, and this subject is of particular interest at the present time, when the European population is rapidly rising in many of the warmer Commonwealth territories.

Dr. Ladell studied the influence of climatic stress on both the Jewish and the Arab population in Palestine, with particular reference to the incidence of "asthenia"—a marked lassitude which is noticeable in summer. Nearly ten per cent of the workers in the railway workshops and docks at Haifa are affected every year with dizziness, lack of appetite, and gastro-intestinal symptoms; after a few days off they can return to duty. The report states: "Subjective lassitude in hot weather is probably linked with subjective comfort standards. Thermal comfort standards are set low in Palestine for both the settlement Jews and the industrial Arab. The settlement worker spends the three winter months in thin-walled, unheated houses, designed for the tropics; the industrial Arab lives in houses equally unsuited to the cold; the thick-walled Arab house is a country manifestation. People in the settlements, especially those who had been in Palestine for some years, stated that they did not feel the cold for two or three months each year. When an individual has become adjusted to a low thermal comfort standard, a rise in air temperature hardly noticed by someone in a higher standard will strike him as being most uncomfortable . . . ; physiological reactions probably follow the subjective feelings . . . The problem of summer lassitude may therefore not be merely one of combating the summer heat, but also one of combating the winter cold, so that the comfort standard is set at a higher level and sudden rises in temperature such as occur with early Khamseens are not then intolerable. The aim must be to retain some acclimatization throughout the winter.

Unrestful sleep and relative sleeplessness in the summer may exacerbate the lassitude. The limiting factors affecting sleep indoors are air movement and wall temperature. During the day the wall heats up in the sun to 50° C. (120° F.) or more; the wall remains hot due to its heat capacity and at night is re-radiating internally as well as externally so that the mean radiant temperature inside the room remains high.

In dealing with housing and building construction, the author says: "A house or factory should be warm in winter and cool in summer; there must therefore be a good thermal barrier between the outside and the inside. This is given in the old style Arab house by the thick limestone walls; in the new houses in the Jewish settlements an attempt is made to get the same effect by the use of two thin walls with an air space in between. But this type of construction is very cold in winter".

A comprehensive study of European life in the tropics was written by Dr. A. Grenfell Price in 1939 ("White Settlers in the Tropics", published by the American Geographical Society). In dealing with house construction, Dr. Price quotes from W. M. Hewetson's "Environmental Influences affecting Blondes in Rhodesa and their Bearing on the Future", published in 1922. Hewetson condemns in round terms the use of the "satanically convenient, but pernicious and damnable galvanized iron, about the best conceivable material for transmitting heat . . . . The man goes out in a pith helmet and leaves his wife and children to stew in an inverted pan". Other things being equal, Hewetson found a remarkable difference in the bloom and appearance of children living in iron-roofed from those living in thatched houses.

These observations on housing and health have a definite bearing on present-day developments in Colonial research. The establishment of a Colonial Research Service has shown that research can no longer be looked upon as a by-product of an advisory department, and regional research organizations are now being set up in the main administrative zones of the Colonial Empire. If economies should be necessary because of financial stringency in the United Kingdom, leading to reductions in the standard of building, this cannot but lead to a lowering of the standard of research. The remark is sometimes heard that the best research work has been carried out in tin huts with the minimum of facilities and comfort, but it seems obvious that if good research work has been and is still being done under poor conditions, still better work would be done if the conditions were improved.

---

* "Problems of Heat Physiology in Palestine". Report to the Colonial Medical Research Committee, 1948, by W. S. S. Ladell, M.D., P.O. Box 607, Jerusalem.

The mental environment is at least as important as physical comfort, and the setting up of inter-territorial research teams counteracts to a large extent the handicaps under which isolated specialist officers in territorial departments have been working during the past quarter century. Collaboration and exchange of ideas between territorial and inter-territorial technical staffs are of the greatest benefit to all taking part, and the success of a regional research organization is largely dependent on its relationships with the territorial departments. The proceedings of two such meetings have recently been published in this Journal, one on fertilizer trials in the October, 1949, number, and one on grassland research in this issue. From these it is possible to obtain a picture of the present state of investigational work in the different territories, and the subsequent discussions bring out points which could only emerge in a round-table conference of the workers concerned.

Discussions like these do much to cure the mental isolation of scientific workers in the tropics, and this factor has been given a high place in the plans for regional co-ordination of research. However well a scientist is housed, however elaborate his equipment and laboratory facilities, he cannot give his best unless he has opportunities for discussing his problems with other workers in the same subject. The research complement of a Department of Agriculture may be not more than one qualified man in each branch; one entomologist, one pathologist, one botanist, etc., and their opportunities for discussion and mutual criticism with corresponding research officers in other territories have often been very few. Even if a regional research organization did no more than bring these scientific workers together frequently, the improvement in quality of work would be noticed in a very short time.

Mental environment is thus an important factor in tropical research, but the past handicaps in this respect can be overcome without difficulty and at small cost. The physical environment, on the other hand, is not so easily made favourable. The chief attraction for scientists in the tropics is the wide range of new and interesting problems, but some of that attraction will disappear if much time is spent in overcoming the petty annoyances which have to be faced by a newcomer. A house or laboratory resembling Hewetson's "inverted pan" is not conducive to the solution of scientific problems, and it must be remembered that clear-headed planning of an investigation is a vital necessity, since the answer cannot be found merely by accumulating a mass of observations and experimental data. We do not imply that every scientific officer should be treated like a delicately brained genius, but he will give better value if he lives and works in reasonable comfort.

In his analysis of tropical neurasthenia, Grenfell Price brings forward evidence which suggests that it is man's reaction to his environment, not necessarily the environment itself, which is responsible for nervous disorders. He suggests that an African living in Europe is just as liable to "tropical neurasthenia" as a European living in Africa, and that the maladjustment of some Europeans to the tropics is sociological rather than physiological. Nevertheless, Ladell's work in Palestine shows that the "microclimate" of an unsuitable house may give rise to physiological disturbances, and it seems clear that both physical and mental environments must be considered when planning research projects.

D.W.D.

NOTES ON ANIMAL DISEASES
XVI—BOVINE BRUCELLOSIS (CONTAGIOUS ABORTION)*

By S. F. Barnett, Veterinary Research Laboratories, Kabete, Kenya

(*Received for Publication on 19th January*, 1950)

Bovine brucellosis is a contagious disease caused by the bacillus *Brucella abortus*. This organism produces characteristic inflammatory and degenerative changes in the pregnant uterus leading to abortion, which is frequently followed by a temporary or permanent sterility. Bulls may sometimes become infected, when abscesses are formed in the testicle and epididymis. The disease is world-wide in distribution and is found in Kenya in both pure-bred and Zebu cattle.

Brucella abortus is a small polymorphic micro-organism, closely related to other members of the group, such as *Brucella melitensis* of the goat, and *Brucella suis* of the pig. *Brucella abortus* is principally a parasite of cattle, but it can cause local suppurative infections in the horse, such as fistulous withers; and it sometimes affects man, causing undulant fever.

The method of infection is usually in ingesting material contaminated with the organism, but it may also occur as a result of the organisms coming into contact with the mucous membranes of the eye or vagina, or even through the skin. The principal source of infection is the infected cow, as the aborted fœtus, fœtal membranes and uterine discharge contaminate heavily everything with which they come into contact. Some infected cows may produce a full-time calf: this constitutes a great danger since its hair and fæces spread the infection without any suspicion being aroused. The aborting cow continues to excrete infection as long as the uterine discharge is present, which is usually for about three weeks, although in rare cases of metritis this may continue indefinitely. In practice, providing no discharge is present, the uterus can be considered sterile 60 days after abortion. Although the organism disappears from the uterus, it continues to live in the udder and associated lymph glands. It causes no observable changes in the udder, but may be continually secreted in the milk, thus forming a source of infection to man. The bacillus thus remains alive in the cow and can reinfect the uterus in subsequent pregnancies, when further abortions may occur.

Bulls may become infected, with the production of cold abscesses in the testicles rendering the animal sterile. Such infections are infrequent, and an uncommon method of spreading the disease; but it is possible that the bull may transmit infection by carrying it mechanically from one cow to another. The general opinion is that the bull is not a serious factor in the spread of the disease, but it is one which should not be overlooked.

Outside the animal tissues the bacillus is not very resistant to destruction. It is fairly rapidly killed by desiccation, sunlight and disinfectants, but in damp shady sites it may persist for months. The disease is, therefore, most likely to spread in Kenya in the rainy season, but infected sheds, manure and drains may maintain infection for long periods, even in dry seasons.

It has been noted earlier that the organisms may be excreted in the milk of infected cows, and it might seem that infection could be spread to other cows on the hands of milkers, but in actual fact this does not appear to occur. Calves reared on infected milk may contract permanent infection, and abort subsequently when breeding age is reached. Whenever in-calf cows are brought into a herd they should always be kept isolated until calving.

Symptoms and Course of the Disease

In first-calf heifers and dry cows the premature swelling of the udder is the first symptom, and a few hours before abortion a sinking of the sacral ligaments and some swelling of the vulva is usually seen. The actual abortion is often preceded by a brownish watery discharge which continues for some days after the calf has been slipped. When abortion occurs before the sixth month of pregnancy, premonitory symptoms are often absent, the only obvious sign of abortion being the discovery of the fœtus.

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* This new article on bovine brucellosis replaces the former article in this series published in this Journal, Vol. 8 No. 2, October, 1942.

Abortions most commonly occur between the fifth and seventh months of pregnancy, although they can occur as early as the third month, or the calf may be carried to full time. Such full-time calves are often weakly and die within a few days. Although most cows only abort once, they remain infected until the next pregnancy, when they carry their calves to full time. Some animals will abort twice and in rare cases three abortions may occur. Parturient disease such as retained placenta, metritis and temporary or permanent sterility are common sequels to infection.

The course of the disease in a herd varies considerably. In some herds it may hardly be noticed except for an occasional abortion or premature calf, but in such herds there may eventually be a "flare-up" with large-scale losses. In other herds the disease may appear with almost explosive suddenness, causing a crop of abortions and possibly no live calves may be reared for two or three years: this loss of calves, together with the loss of milk, and accompanying uterine disease has ruined many dairy farmers in Europe. Fortunately such acute outbreaks are rare in Kenya, but the disease is always sufficiently serious to warrant immediate and continued attention.

Diagnosis

The symptoms of brucellosis are not specific, but since this disease is the most common cause of premature birth, any abortion, particularly after the fourth month of pregnancy, should arouse suspicion. A brownish discharge before and after abortion is fairly characteristic. The fœtal membranes may have patches covered with muco-purulent flakes, and the cotyledons are a dirty yellow colour, rather necrotic and often covered with a greyish-yellow deposit.

The presence of *Brucella abortus* can be confirmed at the laboratory by a bacteriological examination of the fœtus, the fœtal membranes or the uterine discharge, but it is essential that such material reaches the laboratory within 24 hours of dispatch, otherwise putrefactive changes will obscure any diagnostic tests. Another method of diagnosis is the testing of the animal's blood for specific antibodies (agglutins) by the agglutination test. An infected cow usually has some demonstrable antibodies but the titre or quantity of the antibodies varies with the stage of infection. Sometimes antibodies can be demonstrated before abortion but often they are not found until some days after the animal aborts. Following abortion the titre of the agglutins rises sharply and remains high for several weeks, after which there is a gradual decline, usually to a low titre or to a complete negative until the next abortion or calving. The demonstration of antibodies in the blood is used to diagnose infection in a herd and all stockowners should therefore be familiar with the method of taking blood samples and with the principles of the test.

The Agglutination Test

When a suitable suspension of *Brucella abortus* organisms is mixed in a tube with serum containing antibodies in the presence of an electrolyte such as sodium chloride, at a temperature of 35–40° C., the organisms are clumped or agglutinated and settle to the bottom of the tube. The original cloudy suspension becomes a clear fluid with a deposit at the bottom. The quantity of antibodies present is assessed by diluting the serum, and by determining which is the greatest dilution which will still agglutinate the bacteria. In practice agglutination at a dilution of one in ten is not regarded as significant, but if the serum agglutinates at a dilution of one in twenty or higher, the animal is then considered to be infected. Since an animal may not develop antibodies in sufficient quantity to be demonstrable until about ten days after abortion, it is advisable to wait this period before submitting blood for the agglutination test.

Taking Blood Samples for the Agglutination Test

The blood is taken from the jugular vein in the neck. The animal is held by the nose and horns by an assistant who pulls the head round slightly on the side away from the operator. A noose of thin cord is pulled tightly round the base of the neck in front of the shoulder until the jugular vein is seen as a thick cord running down the groove along the lower border of the neck. The skin above the vein is sterilized with methylated spirit or tincture of iodine, which also helps to show up the vein, and a wide-bore sterile syringe needle about 1½ in. long is plunged directly into the vein at an angle of about 30°. With practice the needle can be made to enter the vein directly and blood will flow freely, but on occasions the skin only is penetrated and some exploratory probing may be required before the needle enters the vein. The needle should be quite dry before the operation is started, but in cases of doubt the blood should be allowed to flow for a few seconds before collection.

Blood is collected in sterile *dry* tubes or bottles which can be obtained from the laboratory: 10 to 20 c.c. are ample for the purpose. It is essential that the bottle should be quite dry, otherwise the red cells of the blood will be hæmolyzed and interfere with the test. The container should never be filled more than half full, and after being labelled clearly it should be laid at an oblique angle in a cool, shady place until clotting has occurred. The blood is then dispatched to the laboratory together with the history of the herd or animal, which is necessary for a correct interpretation of the test.

Treatment

There is no effective method of treatment and vaccination of infected animals appears to have no effect on the course of the disease.

Prevention and Control

There are two methods of controlling the disease which are to some extent complementary, since neither method by itself is entirely satisfactory:—

(1) Elimination of all infected animals:—

By frequent blood testing of the whole herd it is possible to eliminate all reactors, that is animals which may be spreading infection. The reactors can be disposed of, or else relegated to a separate and isolated herd.

From the point of view of the state veterinarian and the public health authorities, the elimination of the infected animal is the method of choice, but it is rarely applicable in practice. If the reacting animals could be slaughtered, there is no doubt that brucellosis could be eventually eliminated from a given area, but owing to the high percentage of infected animals in most dairying countries, wholesale slaughter can never be carried out. The practice of clearing up individual herds by selling reactors only disseminates the disease farther afield. There are very few farms which have the necessary equipment and labour to maintain an infected and non-infected herd, and even where it is possible, the anxiety of having a clean and highly susceptible group of cattle in the neighbourhood of infection is enough to deter any farmer from making the attempt.

This method, therefore, although ideal, is not capable of general application. Some areas which initially had a low incidence of brucellosis have been able to eradicate it by a slaughter policy, and many individual farmers in other areas have created clean herds by selling off reactors, but in most parts of the world, control measures are largely dependent on vaccination.

(2) Vaccination:—

A satisfactory vaccine now exists consisting of a living but attenuated strain of *Brucella abortus*. Several such attenuated strains have been employed, but the one most commonly used and which has been subjected to the most critical tests, is called "Strain 19" and was developed in the United States. In Kenya we have been using a similar strain for many years, and from the field results it would appear to be as effective as Strain 19. Both vaccine strains are supplied by the laboratory. The objection to the use of vaccines is that the blood of a vaccinated animal becomes positive to the agglutination test and consequently there are no means of differentiating infected from vaccinated animals. This difficulty has been overcome to some extent by vaccinating animals as calves, as will be explained later, but it complicates the elimination of the disease from an infected herd. It must be emphasized that no vaccine has a 100 per cent efficiency, and that if animals vaccinated against *Brucella abortus* are exposed to heavy infection, a small proportion may become infected and abort, thus prolonging the infection in the herd. The vaccine cannot be used on animals which are more than four months pregnant, since it may cause abortion, and it is necessary, therefore, to protect these in-calf cows from contact with known infected animals. Further, for the purposes of public health, it may sometimes be necessary to identify infected animals. For all these reasons it is advisable that vaccination should interfere as little as possible with the method of blood testing and of identifying naturally infected animals.

It has been found that when animals are vaccinated as calves, of from six to eight months of age, they develop a positive reaction to the agglutination test, but this soon recedes, and most animals become negative to the test up to six months after vaccination. Despite the negative blood test the animals remain immune for up to two years after vaccination. This method of calfhood vaccination has been used in Europe and America for some years, and although it has been exceedingly valuable in controlling abortions, there is growing evidence that in many cases the immunity does not last as long as was anticipated, and it is now suggested that heifers should not be inoculated until they are eight to twelve months old. This results in a more durable immunity, and the blood has usually lost its agglutination titre before the animal is served. A second inoculation is often recommended 60 to 90 days before service, and after the first or second calf has been born, in cases where the cows may be exposed to a very heavy infection. The blood titre following the second inoculation does not persist very long.

Calfhood vaccination can be practised in herds which are free from infection, but which may be liable to infection from adjacent areas. It is a long-term policy of building up a resistant herd. In non-vaccinated herds where *brucellosis* has occurred recently, the owner is faced with a highly susceptible population, of which the most valuable and the most susceptible are the in-calf cows. Those animals which are more than four months pregnant cannot be vaccinated, as the vaccine may itself cause abortion, although such aborting animals are not contagious to others. The uterus at five months of pregnancy seems to be at its most susceptible state for the multiplication of *Brucella* organisms, and it is therefore essential to protect these cows by some means other than with attenuated living cultures. Dead vaccines have been extensively used in the past on pregnant animals, but they probably have little or no protective effect. The susceptible in-calf cows must therefore be protected against infection by other means until they have calved, and it is here that the value of being able to detect infected animals by the blood test becomes apparent. All the non-vaccinated in-calf cows whose agglutination titre is negative may be segregated away from the rest of the herd. This is not an absolute safeguard, since the infected animal may not show a significant blood titre until or shortly after it aborts, and thus an abortion may occur among these susceptible animals. A careful watch for the premonitory signs of abortion such as springing of the udder and relaxation of the pelvic ligament should greatly reduce the chances of infection from this source. Any animal which has aborted, or which shows a positive blood titre should be isolated from the herd, to prevent the spread of infection, and all infected material, such as the fœtus and afterbirth should be burned or buried. The non-pregnant female stock should all be vaccinated immediately brucellosis has been diagnosed in the herd.

Climatic conditions in the drier areas of Kenya tend to prevent easy spread of the disease, except during and immediately after the rains, and therefore, on well-fenced farms there is a reasonable possibility of maintaining a self-contained herd free from brucellosis. If animals are brought into a herd there is a risk of introducing infection, therefore if such a course is adopted, all female stock brought into the herd should be blood-tested before their introduction and preferably kept in isolation until they have calved. If the blood is still negative to the test after calving, they can then be introduced into the herd.

Public Health Aspect

Earlier in this paper it was stated that *Brucella abortus* can infect humans, thus causing the disease called undulant fever. A cow infected with brucellosis will excrete *Brucella* organisms for very long periods in the milk, and is therefore a potential danger to the public if the milk is sold for consumption without previous pasteurization. Farmers, veterinarians and abattoir officials are also exposed to direct infection from the uterus, the afterbirth and the fœtus; therefore the hands and arms should be thoroughly washed in an antiseptic solution after the handling of any material which may be infected with *Brucella*.

MAINTENANCE OF FERTILITY IN DRY COFFEE SOILS

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The application to tropical agriculture of practices well proven in temperate climates involves difficulties which are becoming recognized with greater clarity as the detailed conditions are investigated. One of the most difficult of these problems is that of the use of organic manures, a subject which must remain highly controversial until far more detailed scientific evidence on the conditions ruling in tropical soils can be obtained. The views advanced here are an interim interpretation of evidence which is, as yet, all too slender. They are therefore set out in order to promote thought and discussion on a subject most vital to East African agriculture.

The loss of organic matter from cultivated topsoils is so rapid in the hotter and drier coffee areas that planters require no convincing of the need to arrest it by every practicable method of husbandry. In certain extreme cases, where the loss of organic matter has been followed by severe erosion, the coffee trees are in such poor condition that the conventional methods of ley farming become applicable. A resting period of three or four years under a vigorous grass is a necessary prelude to replanting. Since replanting will then be done with selected strains, productivity of both soil and trees are then raised. The process is, however, expensive, and can affect only a small proportion of coffee in any one year.

To replace lost organic matter in the exposed soil between the trees is a far more difficult matter. Where rainfall is adequate, cover crops and heavy weed growth offer scope for prevention or for easy remedy. In the drier areas which produce nearly half of Kenya's coffee crop, there is not sufficient rainfall to carry both coffee and weeds or cover crops. The drastic crop reductions which can result from weed competition during the rains have been demonstrated by the cultivation trials at the Coffee Research Station, Ruiru.[6] By permitting free weed growth during both long and short rains, and cultivating only twice a year, i.e. at the end of each rains, crop yields were reduced 57 per cent as compared with continuous clean weeding. Slashing of the weeds gave an intermediate effect, 39 per cent below the yields of the clean weeded plots. This depression appears to be due to competition for water rather than for nutrients, since it was unaffected by a dressing of "boma manure" given to half of each of the 81 plots, and the coffee in a neighbouring trial showed no response either to fertilizers or to manuring.[6]

Organic matter thus cannot be grown economically between the coffee trees. It is logical therefore that in these conditions the application of compost or boma manure should have been widely advocated and practised. There is a substantial body of opinion among experienced planters that continuous heavy applications of cattle manure have, in the past, produced excellent results. Although critical evidence is lacking, it appears probable that with sufficiently heavy dressings some important yield responses were obtained. These were, however, achieved when liberal dressings of manure were economically possible. The manure could be purchased cheaply from the native areas, and labour costs were low in comparison with those ruling to-day. Both manure and labour are now in short supply, and it is only in rare instances that coffee planters can obtain or can afford to apply, organic manures even at the rates appropriate to the milder soil conditions in the United Kingdom. The present situation in the drier areas is that dressings of one (4-gallon) debbie per tree are applied, and on many estates even this small quantity cannot be achieved every year for all trees. Even such small dressings entail either heavy expenditure in purchase of manure, or heavy labour costs to produce it on the estate. The purchased material is usually "*boma* manure" i.e. cattle manure which has suffered long exposure to sun and rain in open *bomas*. Analyses of three large recent consignments have shown more than 60 per cent of the dry matter to be earth. The cattle manure prepared on the farm is usually an approximation to "F.Y.M."; employing Napier or other grass instead of cereal straw.

The problem has therefore changed from that of the maintainance of fertility by frequent and generous applications of organic manures to that of an estimate of the effect of admittedly inadequate dressings. On this latter problem a certain amount of valid field evidence is available for Kenya conditions. The results of field trials carried out by the Coffee Services of the Kenya Department of Agriculture are set out in Table 1. This evidence indicates that the application of such small organic dressings to coffee is ineffective as far as improvements in yield are concerned. The trials will continue, in order to investigate the necessity for replacement of topsoil nutrients. The dressings of cattle manure are playing some part in replacement of nutrients, but the labour and expense involved appears to be uneconomic. Similar results have been obtained with coffee in India.[1] This evidence is in marked contrast to those vigorous responses obtained by several workers from cereals and from cotton in East Africa.[9]

We suggest that the explanation is to be found in the physical conditions existing in the topsoils, and in the root distributions of the different crops. Whereas as cereals and cotton have a relatively brief and critical stage in their growth, during which most of their feeding is done within a foot of the surface, coffee flourishes only on very deep soils. The most important coffee soils are deeply-leached lavas, often extending to depths of more than 30 feet. Root studies,[5][8] show that coffee has a dense surface mat and a system of vertical roots extending to depths of 15 feet or more. Organic dressings cannot be deeply incorporated in coffee topsoils without excessive damage to the surface root-mat. The manure lies within the top few inches of exposed soil, where, apart from the relatively brief intervals of the monsoon rains, it is often to be found as hard dry fragments, inaccessible to the live roots at greater depths. The drying out of the surface soil is accelerated both by weed growth and by the cultivations necessary to destroy weeds. The temperatures reached in the soil surface are remarkably high. From daily readings over the past three years we have frequently observed temperatures within the top centimetre of over 140° F.; on 37 per cent of days in a year the temperature within the surface soil exceeded 120° F; and on 75 per cent of all days observed it exceeded 100° F.; this was at 5,700 feet at Kabete, and there is little doubt that these values are exceeded in the lower coffee areas. Under this roasting the losses of organic matter and of physical structure are acute. In the first two years of the cultivation trial already quoted[6], the clean weeded plots lost one-quarter of their non-capillary pore-space, i.e. of the spaces through which air and water enter the soil. Work is not yet completed on the numerous samples taken in the third year, but the dusty appearance of the clean cultivated topsoil is now even more striking.

It is thus clear that as an essential operation of good husbandry, the coffee planter must take active steps to modify these fiercely unfavourable conditions in the topsoil. This can, of course, be accomplished by mulching. By collecting the maximum available quantity of grass, straw, rushes, stover or any other vegetable trash, and omitting the preliminaries of the compost heap, the planter can apply these materials to protect the exposed soil between the coffee trees. The soil is thus protected from direct radiation, and from rapid drying. The surface root-mat of the coffee is given many extra weeks of feeding in the relatively rich topsoil. The coffee roots will, of course, exhaust this water supply in time, but soil sampling under mulched coffee has consistently demonstrated[6] that the topsoil remains at the limits of root-drying, known as the "wilting point". This for Kikuyu Red Loam, is about 22 per cent of water in the top six inches. Bare soil, however, was found dried out to between 6 per cent and 10 per cent. This deficit must be made up, when rain again falls, before the plants can begin to benefit. This drying effect has been traced to a depth of three feet. Although a heavy trash mulch does intercept very light rainfalls, and permit them to evaporate without benefit to the roots, the dry layer of topsoil acts in the same way.

The trash mulch also has a striking effect on the penetration of rainfall, especially in dusty over-cultivated soils. A field trial of mulching treatments now in progress at the Coffee Research Station, Ruiru, has been laid down on soil of very poor structure, suffering from past erosion[7]. The recent "short rains", which amounted to nine inches in all, were found by soil sampling to have penetrated to a depth of 4 ft. 6 in. under a 6-in. mulch of Napier grass (*Pennisetum purpureum*), to 2 ft. 6 in. under loose, recently cultivated bare soil, and to less than 1 ft. 6 in. in the bare soil, trampled by pickers. Since the rains occurred during the local picking season, this latter soil condition was typical of much of the drier coffee areas. It is probable that this difference is due mainly to the "puddling" and "capping" of dusty surface soil under the violent impact of tropical rain. The grass mulch protects the soil from this physical battering, and substitutes a steady percolation. The importance of this improvement in penetration needs no stressing from the viewpoint of soil conservation.

Yield trials support the conclusions from the soil observations. Evidence is, as yet scanty, but the results available are set out in Table 2.

A common factor in these experiments has been the application of mulch after the final cultivations for weed destruction at the end of the rains. To assist penetration of rainfall and to conserve both soil and moisture, it is obvious that mulching can, with advantage be done at the beginning of the rains. This is not at present plantation practice, but this treatment has been included in the factorial trial referred to above[7]. It is probable that responses will be greater with early mulching, while the suppression of weeds will reduce the need for cultivation.

It is clear that under dry conditions the opportunities of obtaining a yield increase from a given quantity of grass are greater when it is used as a mulch than when it is composted and dug in. We do not suggest, as a conclusion, that cattle manure should not be applied, but rather that it is unlikely to produce responses unless it can be covered and protected by mulch, and maintained in a moist condition in which roots can reach it. For the reasons set out above, we believe that, in the dry areas, the best results from the grass and cattle manure available will be obtained by discing or forking in the manure and covering it with grass, rather than by combining both in the compost heap. The whole operation should be completed in dry weather preceding the rains.

The practical difficulties are admittedly great, but they may be overcome by energy, initiative and organization as may be seen on a number of progressive estates. Bush-clearing and stump-clearing of every spare acre, so that it may be mown mechanically; the planting of vigorous and bulky grasses in every spare corner; the devising of sleds or low-loading trailers, or even the adaption of binders, to facilitate handling of very large bulks of grass, and to avoid double-handling; all these are less easy than the purchase of manure or fertilizers, but they are far more likely to produce the required results in the dry areas. Where land is not available on the estate, either the leasing of land elsewhere or the outright purchase of grass are alternatives to heavy outlays on manure. In order to make the best use of land available for the growing of mulching materials, the application of fertilizers to the grass crop offers more certainty of a return than does their direct application to the coffee. Coffee has given little or no response to fertilizers on the Coffee Research Station at Ruiru but a trial with maize grown for silage showed large responses on the same soil. This is, we believe, an accepted practice among sugar-planters in the West Indies, who fully realize the value of mulching. It must be remembered that as the grass eventually breaks down, its mineral contents are contributed to the soil. Sampling and analysis of the Napier grass mulch applied to the experiments at the Coffee Research Station, Ruiru, illustrate this point. In order to obtain the minimum four-inch cover over the exposed soil to within eighteen inches of the trees, about 27 tons per acre of newly cut Napier grass were required. This grass had been wilted for one week after cutting. Full sun-drying later reduced this weight to under 12 tons per acre, which emphasises the need to avoid the transport of surplus water. The ash content was 1.37 tons per acre, and had an average content of 1.95 per cent of P_2O_5. The mulch was thus equivalent to a dressing of 660 lb. per acre of phosphoric oxide, i.e. to about 2 cwt. of bone-meal or 2½ cwt. of Seychelles guano. The nitrogen content of the sun-dried grass was approximately 88 lb. per acre, equivalent to over three hundredweights of sulphate of ammonia. If the prices of such fertilizers are considered when judging the cost of mulching one acre of coffee, the operation assumes a more economic aspect. Grass mulches can thus play an important part in the replacement of nutrients removed by the coffee crop. Such heavy withdrawals of nutrients from grass-producing areas must, however, be replaced if annual grass crops are required. Even with the very best organization it is improbable that annual all-row mulching will be achieved in the dry areas until the acreage of productive grass approximately equals that of the coffee. Taking two cuts a year, this ratio may be improved in good seasons, but in the drought year of 1949, with a rather poor area of unfertilized Napier grass, nearly three acres were required for one acre of all-row mulch. Alternate row mulching is clearly the best distribution of a limited quantity of material, since each soil area is thus protected in alternate years. It should be regarded as the minimum rather than the optimum treatment. We need to know in detail the effects of alternating biennial cover on the surface root system of the coffee trees.

The difficulties of collecting the material emphasise the need to conserve mulch after it is laid, i.e. to avoid, rather than to promote, its decomposition. Suppression of weeds is usually achieved by the mulch for the first rains only. It is subsequently necessary either to hand-pull the weeds or else to rake aside the mulch, disc the weeds and return or replace the grass. The possibilities of mechanising this whole process appear to be worthy of study. Weed killing by sprays on top of the mulch will be useful when grasses can be attacked. Preliminary tests with oil sprays including penta-chlor-phenol and "2-4-D" have not yet succeeded in the control of "couch" (*Digitaria abyssinica*). Where there is ample mulching material, the old mulch can be disced-in, but a dressing of from one-half to one hundredweight of sulphate of ammonia given on the mulch before discing, is then advisable in order to avoid a shortage of nitrogen arising from the burying of much unbalanced carbon.

Many planters will object that they prefer to have organic matter in their soils rather than dry litter weathering away on top. A comparison of the topsoil under mulch, with that given the usual one or two debbies per tree of manure, if carried out during a dry spell, will reveal that the topsoil under mulch is full of live roots, while that unmulched is hot, dry and inert, in spite of the manure. Much American evidence, and perhaps more directly applicable studies by Martin[3] in Uganda, have shown that live roots are far more effective than is buried organic matter in the improvement of soil structure. McCalla[4] has shown, by a most ingenious series of experiments, that the clear colloidal solution washed out of decaying straw mulch can greatly improve the structure of soil. Soil structure measurements recently taken in Kenya coffee, mulched in alternate rows, are giving interesting results. Very significant differences both in dry and in water-stable crumb structure are found after a single year of grass mulching. In the field trial at Kitale, where mulching contrasts have been continued for six years, soil under mulch now contains more than twice the proportion of water-stable crumb found in the bare soil.

In conclusion we must emphasise that the foregoing discussion relates to the dry areas in which soil moisture is the limiting factor in coffee production. Conditions are very different in those fortunately situated plantations where there are both suitable temperatures and also water to spare for weeds or cover crops. Although such areas are comparatively small among the European plantations, they are extensive in certain native reserves where coffee-planting is being developed. Under these conditions, small dressings of cattle manure or compost produce striking volumes of weed or cover growth, whose roots, and to a lesser extent, tops, provide organic matter in quantities large enough to be fully effective in maintaining soil fertility. Soil conditions in such areas are far closer to those ruling in temperate climates, and the application of traditional European methods of husbandry has often met with striking success.

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Note.—All the experiments quoted in Tables I and II have been described in Annual Reports of the Kenya Dept. of Agric.

TABLE I

EFFECTS OF SMALL ORGANIC DRESSINGS ON THE YIELD OF KENYA COFFEE

Experiment Station and Altitude	Mean and Extremes of Rainfall During Trials	Design of Experiment	Number of Plots	Number of Annual Yields	Annual Dressings per Tree	Per Acre	Effects on Total Crop	Observations
Thika Substation. 5,100 ft.	Mean 33″. 18″ to 40″.	Randomised Blocks. 4 reps.	24	6	2 debbies cattle manure.	6 tons	+2·3%	1938–1943. Small responses in two single years. No statistically or economically significant response over six years.
Ruiru C.R.S. 5,400 ft.	Mean 36″. 25″ to 52″.	3 x 3 x 3 4 reps.	108	3	0, 1, 2, debbies dairy compost.	3½ tons and 7 tons.	—2·4%	1947–1949. No sign of response in three years.
Ruiru C.R.S. 5,400 ft.	Mean 28″. 25″ to 31″.	3 x 3 x 3 x 3 split plots.	162	2	1 debbie cattle manure.	4 tons.	+1·4%	1948–1949. No statistically or economically significant response in either year.
Kabete S.A.L. 5,700 ft.	Mean 41″. 31″ to 50″.	2 x 2 single rep.	4	5	2 debbies compost.	6 tons.	—3·8%	1938–1942. Uneven, no overall response.
Kitale Exp. Farm. 6,200 ft.	Mean 46″. 39″ to 53″.	5 x 5 Latin Square.	25	5	2 debbies compost.	6 tons.	+3·1%	1944–1948. No statistically or economically significant response in any year.

TABLE II

Effects of Trash-mulching on the Yield of Kenya Coffee

Experiment Station and Altitude	Design of Experiment	Number of Years	Average Responses from Mulching	Observations
Makuyu Substation. 4,800 ft. ..	4 x 4 Latin Square	3	+12·1%	1940–1942. Controls were box-ridged.
Karimani Substation. 5,100 ft. ..	Randomised block. 4 reps.	4	+ 9·6%	1940–1943. Comparison of mulch with trash dug in.
Ruiru C.R.S. 5,400 ft.	4 x 2 x 2 x 2 2 reps.	1	+12·9%	1949. Mulching given one month late through failure of rains.
Kabete S.A.L. 5,700 ft.	Randomised Block. 6 reps.	6	+55·3%	1940–1946. Consistent large responses; controls were box-ridged.
Kitale Exp. Farm. 6,200 ft. ..	Randomised Block. 6 reps.	7	+18·6%	1943–1949. For mulch between trees; smaller responses from complete mulch and for mulch under trees.

Even greater responses by coffee to grass mulching have been reported by Gilbert under Tanganyika conditions (2).

THE SEA FISHERIES OF KENYA

By Hugh Copley and T. E. Allfree, Game Department, Kenya

(*Received for publication on* 11*th September*, 1949)

The possibilities of the utilization of the sea fishes off the coast of Kenya has been discussed since 1928 but it was really the late war that focused attention on this matter. Since the war much discussion has taken place and various attempts have been made by individuals and commercial interests to make wealth out of our sea fishes. Our newspapers have also shown great interest in these matters. The time seems appropriate to examine the possibilities for the utilization of our sea fishes and to put before the public a comprehensive view of the whoe question and to discuss the various methods by which advancement can be made.

In 1928 the Government of Kenya agreed and asked Dr. Cecil von Bonde, the then Director of the Fisheries and Marine Biological Survey of the Union of South Africa, to make a survey of the Marine Fisheries of Kenya. Dr. von Bonde made a survey, the results of which are incorporated in a report entitled "Report on a Preliminary Survey of the Sea Fisheries of Kenya Colony". The conditions under which Dr. von Bonde worked were not conducive to a thorough examination of the question, neither was enough time allowed for doing the survey properly. However, Dr. von Bonde laid down a few valuable recommendations. They were, (1) no possibiities of developing a trawling industry; (2) the substitution of the present imported dried fish industry by locally caught and processed fish; (3) the conversion of any surplus fish into fertilizer, and (4) far more research.

In 1932 and 1934 the then Governor of Kenya, Sir Joseph Byrne, discussed this report and the whole question of sea fisheries during visits to the coast, but no money could be provided for this work owing to the financial depression existing at that time.

In 1942 Government started a fishery at Shimoni, 50 miles south of Mombasa, with a European officer in charge, and also appointed the Hon. S. V. Cooke, M.L.C., as Controller of Sea Fish. The object was to supply fish especially to the armed services. Investigations were also made as to possibilities for starting a shark liver oil industry, as well as the use of seaweed for the production of agar agar. In 1946 Government disposed of the Shimoni plant to a company by the name of Ocean Fisheries, Ltd.

In order to develop the native fishing, Government started a fishery centre at Malindi with an Assistant Fish Warden in charge, and in 1949 the station was strengthened by the "Menika", a 35-ton motor fishing vessel. In other words a very definite start has been made to improve the native sea fishing industry.

The main reason why our sea fisheries should be developed is, of course, that Kenya lacks proteins to meet the rapidly growing demands for a more rational diet for native consumption. This is especially the case when native labour is being employed on sisal, tea and coffee estates, by the railway, and by other employers of labour. Added to this there is a large potential call for protein food as fish meal in the diet of all livestock. Although these demands are great, any excess of fish production can be absorbed as fish fertilizer. It is believed that the potential demand is about 50,000 tons a year as a bare minimum. The total tonnage of wet fish to meet this demand would be in the neighbourhood of 120,000 tons.

No mention has been made of fish sold to towns for consumption as fresh fish. This is consumed mainly by the European and Goan communities. As the wages of the educated African rise, fresh fish will come within their economic reach and consumption will go up. To whatever figure it rises, it must not be forgotten the amount of fresh fish consumed is unlikely to exceed five per cent of the total catch. Therefore the main development will be in the dried and salted fish trade, fish meals and fertilizer.

There is another reason for the development of our sea fisheries. For the past 12 years those persons with experience of the Kavirondo Gulf fisheries of Lake Victoria have been very concerned at the fall in productivity of the native *Tilapia* fishing. (Productivity is a measurement of the number of Tilapia caught in a standard 5 in. gill net per 24 hours.) This may mean that the stock of legal sized Tilapia in Kenya waters cannot stand the present fishing effort. Should research prove that this is the case then the only way to save the fishery would be by restrictive legislation. If there were ample stocks of sea fish available then restrictive legislation would not affect the overall position in Kenya. It must be remembered that the fisheries based on the Kenya shoreline of the Lake should provide for from 200,000 to 300,000 natives before any fish should be moved outside the area.

Description of the Coast and Fishing Grounds

The coastline of Kenya consists for nearly all its length of an upraised beach of old coral. The height of this beach ranges from 10 to 30 feet. The base of the coral cliff is continually being undermined by wave action, with a consequent fall of rock as soon as support has been removed. From the upraised cliff there is a narrower platform, and the water deepens to as much as five fathoms at H.W.T. to the outer fringing reef. These fringing reefs vary from 400 yards to a mile from the shore. They are only exposed to any extent at the low water spring tides. To the seaward side of these fringing reefs the shoreline falls abruptly and the 100 fathom mark is hardly more than four miles whilst the 400 fathom line is not more than five miles from the shore. The exceptions to these general features are Vanga Bay, the Malindi Bank, Formosa Bay, and further north Patta Bay with its islands. To the south of the Colony, Pemba is divided from the mainland by a deepwater channel called the Pemba Channel with water from 200 to 400 fathoms in depth. Zanzibar, on the other hand, is on a plateau divided from the mainland by very shallow water not much more than 20 fathoms anywhere and generally much less.

Vanga Bay has an average depth of 15 fathoms and can be considered to extend from Chale Point to the Nyama Reefs which are practically opposite Tanga. The bottom is marked shell and sand on the Admiralty charts, but this uniformity has yet to be proved.

Formosa Bay is really a continuation of the Malindi Bank stretching northwards to the Zewoyu Reefs. The 100 fathom mark where it nears the Zewoyu Reef swings out to sea in a big curve and approaches the coast again just north of Patta Island, so this ground is really an extension of the Formosa Bay ground. Formosa Bay itself is shallow, of an average depth of 10 fathoms, and the bottom is fairly clear, being composed mainly of Sabaki River mud. Off the Zewoyu Reefs there may be trawling grounds down to 140 fathoms, but in many places the ground is very foul and would need a great deal of charting to make it safe for trawler work.

Patta Bay is shallow, about five to seven fathoms, but what the ground is like down to the ten-fathom mark is not known.

Right down the coast from Cape Guardafui to the Zanzibar Channel, or plateau, runs a broad pathway from the 20 to the 300 fathom line. Down this pathway pass the pelagic migratory fish during the N.E. monsoon. What occurs during the S.W.monsoon no one knows and that is one problem awaiting solution.

Description of Various Types of Native Fishing Gear and their Use

The various methods of catching fish by the native fishermen are far more numerous than the average person realizes. Some are ingenious but practically all have been in operation for many years. They can be classified as the use of nets, handlines, fixed traps and movable traps. The use of some types of gear is restricted to definite localities whilst other types are in use throughout the whole coastline.

One of the most popular fishing nets is the "Juya" or pocket seine, which is used along the whole length of the Kenya coast, although mesh size and material used vary in different localities. It is a pocket seine employing the same principles of beach seining nets used in other parts of the word. There is a large central rectangular bag of netting 13 ft. 6 in. with a depth of 7 ft. From the two sides extend wings, each 4 ft. 9 in. wide, to guide the fish into the central bag. To each wing is attached a long rope of about 500 yards in length. A typical net would measure 90 feet from wing tip to wing tip. The warps are generally made of twisted Dohm palm leaf whilst the netting is braided of the same material with pockets of sacking. In the higher quality net, both wings and bags are of coir twine. Long cylindrical wood floats (roots of a very light species of mangrove tree) are attached to the head rope, whilst the foot rope is weighted with small pieces of coral.

Juya seines are used in the calm water between the reef and the shoreline, preferably over a sandy, weed-sprinkled bottom, but they are occasionally shot over coral where the bottom is reasonably flat. The latter, however, causes the net to be caught up frequently and requires constant diving to free it. This causes such delay in the hauling operations that many fish escape over the warps. A shallow draft boat is used to move the net, warps and crew to a selected area. As the operation of this net requires shallow water it is worked between half ebb and half flood tides. When the selected area has been reached three men are dropped over the side of the boat on to a sandbank or on to the beach with one end of the rope. The boat then puts off, playing out the warp until the end attached to the first wing is reached. The net is played out, and as the last wing of the net is shot one end of the second warp is attached, and the boat makes for the sandbank or the shore. Two divers are dropped whilst the net is being played out, whose duty is to swim behind the pocket and clear obstructions. If the laying of the net has been well judged this second warp will end within a few yards of the three men holding the first warp. Both ropes are hauled in until the net reaches the shore and the mouth of the bag can be closed. The principle embodied in the net is that the warps must move and vibrate in the water, and when they do fish will not readily pass over them. As hauling goes on the area decreases until finally those fishes which have lacked sufficient courage to rush over the vibrating ropes are guided by the wings into the bag. Provided the bottom is not troublesome several shots can be made during a tide, and catches of 1,000 pounds or more are not unusual.

The "farije", gill or tangle net, is only used for shark fishing. The largest operations of these nets are in the dried fish trade operating on the north coast of Kenya. Various sizes of mesh are used varying from a 2½-in. to a 6-in. bar. Each size of mesh has its own Swahili name, but the most common is the 3¾ in. to 4 in. mesh called "sonyi".

The best nets are made from locally plied cotton thread imported from India whilst less costly and poorer quality nets are braided from sisal twine. Good strong nets are also made from the thread laboriously extracted from old lorry tyres and are the cheapest in price.

Tangle nets are fished in sections of an average length of 15 fathoms when set on the headline. A fisherman will use as many sections as he can afford to make. From ten to 15 sections are fished from the larger boats, so 450 yards of net may be in the water at any one time. The net is set on the head rope by a third and allowed to hang free—no foot rope is used. An anchor in the form of a large stone is dropped in up to 17 fathoms of water. To this anchorage is attached a rope and buoy. The head rope of the net is made fast to the anchor rope at the depth it is desired to fish the net—usually near the bottom. A section of 15 fathoms of net is shot, and the other end is attached to the second anchored buoy rope, and so on. Pieces of bait in the form of fish or shark offal are sometimes tied to the net. Shark and dogfish are caught by getting themselves gilled or tangled in the netting.

The "Nyafu za Mirama" or ring net is used mainly on the South Kenya coast and was introduced from Tanganyika and Pemba Island. Typical specifications for a net is 45 fathoms long of 1¾ in. bar mesh by 45 meshes deep, usually made of light but strong lorry tyre thread.

The net is used to encircle fish in shallow water by shooting the net from the stern of a canoe. Having encircled the fish they are caught by moving one end of the net round the outside of the circle and working the other end of the net round the inside. Care is taken to keep the footrope on the bottom. The operation continues until the net is so small that the footrope can be closed and the fish lifted out of the water in the pocket thus formed. This is a highly skilled form of fishing. Quick, silent, organized action is required to encircle the fish and no mistakes must be made. The junior author of this paper saw nine hundred pounds of koli koli (*Caranx* sp.), engrossed upon feeding on sardine in shallow water, caught in this net in one operation.

Various other nets are used such as small pole seines which are made of lorry tyre threads, or Indian imported cotton thread. Even strips of bark are used by the poorer Bajune fishermen.

The hand circular casting net is mainly used for catching sardines when in shallow water, and by line fishermen to secure small fish for bait.

Various types of traps are used. One of these is the "Tata", "Tanda" or movable "Osia". This is a form of keddle trap which is set at low tide on sandbanks in the shape of a huge "V" with a 9 in. gap leading into a small circular enclosure at the apex. The arms of the "V" may be each 300 yards long and are constructed from the fine stick-like centres of Dohm palm fronds held together in the form of a mat. This pliable fence is made in sections of about 12 yards long by 4 ft. deep, which can be rolled up for ease of transport. The compartment at the apex of the "V" is built of sticks of 6 ft. or 7 ft. long. When the net is erected these are placed first on the lowest slope of the shore. Stakes to which the wing matting is to be secured are driven into the sand forming the arms of the "V". These are always placed across the path of the incoming tide. The matting is tied at the top and bottom to the stakes, forming the arms of the "V" furthest from the approaching tide. The arms nearest to the incoming tide have the matting laid flat on the sand and are fastened to the base of the stakes only. The flood of tide keeps this mat submerged allowing fish to pass over and into the "V". The ebb tide turns the matting back and stands it upright against the stakes. The fisherman then comes and ties the top of the mat to the top of the stakes and the fish are trapped. As the tide continues to ebb the water recedes in the direction of the apex; when it is low enough the fisherman enters and secures the catch. This type of trap takes three or four men to work and requires a large flat-bottomed boat to move it to fresh areas. It is sedom fished for more than two tides without being moved, as the fishermen believe the fish soon get to know the location of the trap and avoid it. The catches can be considerable, a thousand pounds in one tide, but like all forms of fishing it has its bad days when only a few pounds of fish are caught. It is, however, one of the most steady forms of catching fish, averaging about 120 pounds daily with a good trap set in a good region.

The trap which visitors to the coast always see is the "Osia" or fixed stake trap. It is a complicated trap with many small but important features which space does not allow to be described. Briefly, it consists of a single line of sticks from 8 to 10 feet high, which runs out to sea from high water to just below low water. The seaward end of this arm divides the narrow doorway of a small circular enclosure of tall stakes into two halves. From each side of this doorway a short arm protrudes a distance towards the shore at an angle to the main fence. As these traps are generally built in the calm waters of an estuary, fish moving with the tide and keeping close to the shore encounter the fence and, being determined to get round it, swim along it and are guided into the compartment. This occurs at both the making and the ebbing of the tide. The trap is expensive to build and to maintain, and lasts only about a year. Some traps average 15 to 20 pounds of fish per day over the year, whilst others catch much less. The catch of the trap depends on its site. Occasionally a large haul of a ton or more fish is taken should a shoal of mullet get caught.

Another common trap is the "Maema" or fish pot. This is a wickerwork fish pot which can be seen in use along the whole length of the coast. Constructed from various materials and always hexagonal, with one or two valve entrances, they vary in size from two feet across the top to eight feet. The bait used is crushed shellfish mixed with the leaves of a mangrove tree; the latter stop the bait being washed away. Where shellfish is not available, the pots are baited with a particular seaweed (*Ulva* sp.) favoured by the "Taffi" (*Siganus oramin*). When shoals of anchovy (Kombo) visit the coast, and can be easily caught, pot fishermen prefer them to all other bait and they seem to think them more effective as bait when they have reached a very unpleasant degree of putrefaction. In good areas these pots will average 4½ pounds of fish per pot per day over the year.

Last to be described is "goggle fishing". This method of coastal commercial fishing originated among the Wadigo at the village of Galu near Diani. They learnt by watching the Japanese divers spearing fish in pre-war days. This method has developed into a specialized form of catching crawfish and does in fact form the backbone of the crawfish industry of the coast of Kenya. Goggles have two eye-pieces and are home-made from horn or carved wood inlaid with glass—generally from secondhand spectacles. A long barbless spear is taken, chiefly for protection and also to spear fish should they present an easy target during the crawfish operations. A small net and a cloth, with which to pull the crawfish from their holes, complete the equipment. The fishermen work in pairs. When a rock is discovered with crawfish hiding in it they dive and set the net in front of the holes and bolt the crawfish into it by judicious poking of the spear. Should this not be possible the cloth is wrapped round the hand and the crawfish pulled out. Occasionally a live octupus is tied to a stick and thrust into the holes to bolt the crawfish into the net, in much the same way as a ferret is used when rabbiting. We may add that the octopus is the deadly enemy of the crawfish. Crawfish are never speared as they must be sold alive. In the best areas a man can catch from 30 to 40 pounds in a day.

In line fishing the native craft called "ngalawa" is used. This is a dugout with two outriggers and is fitted with a lateen sail. The "ngalawa" is used anchored with sail down or sailing towing from two to three lines. The only recent innovation is the use of the "hori". These boats are built, I believe, in Kutch. They are brought to the coast by the owners of the big dhows. They are beautifully made in two sizes, very much on the lines of an American birch bark canoe. These boats catch the great majority of the kingfish landed, and six "horis" will catch 700 pounds of kingfish in the morning. These little craft were introduced about 1932 and their use has greatly extended, and incidentally their price has risen from 60 to 500 shillings each due to the rigid control of timber in the exporting country. There are other minor fishing methods but those described are the main.

Types of Fish Available

In tropical waters there is generally a multiplicity of species of fish available but relatively speaking the number of fish in each species is small. In temperate and northern waters the number of fish in each species is usually enormous but the number of species is relatively small. One species will support an industry, i.e. herring, hake, cod, halibut, pilchard, etc.

The fishes of the East African coastline can be roughly divided into four groups: the pelagic fishes; the bottom feeding fishes of the seaward side of the reefs; the fishes of the inner coral reef, and the fishes of the mangrove swamps. Of these it is thought the future rests mainly with the pelagic fishes.

The coral fishes of the inner reefs are all small highly coloured fishes principally the Rock fishes (*Scorpæna*), the Trigger fishes (*Balistes*), the Gurnards (*Trigla*), the Flatheads (*Platycephalus*), the Wrasses (*Lepidaplois*), the Greyskins (*Plectorhynchus*), the Surmullets (*Parupeneus*), and numbers of the smaller Snappers (*Serranus* family). As these waters can be fished during both monsoons they are actively exploited by all types of fishing, and provide the fish which is eaten by the fishermen themselves and by the local inhabitants.

Next to the pelagic fishes the bottom feeding fishes of the seaward side of the reefs are the most important from an economic point of view. They are caught in from 10 to 20 fathoms of water, but during the S.W. monsoon the native fishing craft cannot stand the seas, so these fish are principally caught during the N.E. monsoon. Most of them range in weight from five to 25 pounds but some of the rock cods reach a weight of from 100 to 200 pounds. All are firm fleshed and of excellent quality from the market point of view. The principal species are the so-called Rock Cods (*Epinephelus*) and the Snappers (*Lutianus, Pagrus, Sparus, Dentex, Pagellus, Pomadasys* and *Lethrinus*). All these fish, if iced properly, are acceptable to the public and they are also good for salting and smoking. This line fishery is worthy of a large development.

With regard to the pelagic fishes, it must be understood that from November to April there is a migration of small herring-like fishes called "seemu" and "kombo" by the native fishermen, belonging to the genera *Clupea, Pellona* and *Atherinus*, which move down the coast. It is upon these shoals of small fishes that the pelagic fishes feed. Often the shoals of "seemu" and "kombo" are from five to 40 acres in extent and the number of these shoals varies from year to year depending on the quantity of plankton in the waters. Consequently the number of large pelagic fish also varies from year to year. It must be remembered that even in a bad year the fish would run into thousands of tons. These shoals of migratory fish are composed of, firstly, the Kingfish (*Scomberomorus commersoni*) which is a prime market fish running from six to 30 pounds. Then there is the Pandu (*Chorinemus lysan*), and the various koli kolis (*Caranx*). These are caught by the native fisherman towing a bunch of "seemu" from a sailing ngalawa. They could also be caught in large quantities given the right methods. There are, however, other fishes, the importance of which has only lately been realized. They are Oceanic Bonito (*Gymnosarda*), the Bonito (*Sarda sarda*), *and* the long-finned Tunny (*Germo alalunga*). The Bonito weighs from three to five pounds, the Oceanic Bonito from seven to 17 pounds and the long-finned Tunny is usually from 28 to 32 pounds. How these are to be caught in commercial quantities is discussed later in this article; the main point is that they are available. There are other pelagic fish, of course, such as the Sailfish (*Histiophorus gladius*), the Runner (*Elagates nigra*), and many others which are caught, but the main standby will be the "seemu" themselves, the kingfish, the various *Caranx* and the various small tunnies. Whether they are in sufficient quantities to give us 120,000 tons of wet fish per year is not known but this question should be one of the main objects of an investigation unit.

The fishes of the mangrove swamps are as yet unexploited, but their value is beginning to be realized. The principal places which could be developed are Vanga Bay, Gazi Bay, Fundisha Bay and Lamu. The importance of these places lies in the fact that they provide calm water conditions during the S.W. monsoon. The principal fish are the mullets (at least five different species) and the Milk Fish (*Chanos chanos*). Already various methods have been tried out to take these, so far with encouraging success, but more work has to be done before final success is achieved. The average size of the mullet is an excellent one for the market. It has good keeping qualities and is a first class eating fish.

The other potential source of fish food in these localities is the development of fringing fish ponds. These are fed by sea water at high tide bringing plankton food into the ponds. The procedure is to take a determined number of fry based on the acreage of the ponds, and when they have reached a proper size they are seined out and sent to market. In other words the whole of the growth is controlled irrespecpective of the monsoons, and fish are available (on a rotation basis) when they can be absorbed by the market. Work is already in hand by private enterprise to test out this method of producing fish.

In addition, fishing for the various sharks, dog-fish, skates and rays holds promise. From the little work that has been done it must be realized that sharks, at least those which have been investigated, are migratory in their habits. Trials have also shown that the livers of the majority have a low vitamin content and are not a paying proposition. However, all these fish are food for the native population. Various improved types of gear for catching shark have been demonstrated but time is required to get the native fisherman to adopt them. No comment has been made on the crustacea and other minor products of the sea, as these would require an article to themselves.

Commercial Exploitation

This is divided into two sections, (1) the native fishing industry, and (2) commercial fishing in charge of and under the supervision of Europeans. Bearing in mind that the potential requirement is 120,000 tons of fresh fish per year, we can examine these two totally different kinds of production. The present output of the fishermen of the coast of Kenya is about 2,000 tons wet fish per annum. The present importation of dried fish is about 1,400 cwt. of fish, principally from Aden and the Persian Gulf. The total amount of fish shipped up-country as fresh fish is between 100 tons and 150 tons per year. The rest of the fish is therefore consumed on or near the coast. The question arises as to whether the native fishing can be rapidly expanded to produce 120,000 tons of wet fish per annum. If, by the efforts of Government, the native fishing industry can be increased by a steady ten per cent each year, that is all that can be hoped for. Therefore the tonnage aimed at is beyond the native fishing industry for many years.

The only way then to get the required tonnage is to utilize commercial interests to the full. It must be remembered that the actual catching of the fish is only one part of exploitation. When the fish have been caught and landed on the pier facilities for storing the catch which is unsold must be provided, whilst arrangements must be ready to market the catch locally and for distribution. These arrangements must cover proper transport for the up-country markets, which also must have proper facilities for holding a stock of fish. Other portions of the catch have to be salt-cured. Portions of the catch have to be made into fish meal, and the rest, or offal, made into fertilizer. All these processes mean a knowledge of the trade and, much more to the point, adequate finance.

We believe we can state the case on behalf of the commercial interests like this: "We (commercial interests) believe there are potential sources of fish in the sea; we believe these should be utilized but we would point out that there are no data regarding the bulk available in the sea, the migrations and seasons, and, as these seas have never been exploited by modern methods, the best ways to catch the fish. If Government can and will do the preliminary investigation work and give us this information we can judge whether we will receive a reward for our financial commitment". In other words there should be a division of endeavour; Government to do the investigation, commercial enterprise to follow up with exploitation. It must be realized that should this point be reached, Government investigation would still carry on getting and giving information to the commercial interests. Such a project does not in any way conflict with the native fishing industry. We hope that with Government guidance the latter will develop the inner reef and outer reef fishing and the mangrove fishing, which will be within their compass. There is plenty of fish for both for many a year to come.

Research and Investigation

It is hard to say where the dividing line is between research and investigation, but for our purpose we will consider research as fundamental biological research, and investigation as the actual methods used on an experimental basis to find out the right places to fish and the right fishing methods. In the case of the sea we must remember that we are not faced with a problem of overfishing, or restrictions, etc., is that fundamental research can be the hand-maiden following up investigation.

It can be suggested that what is required for investigation is firstly a fishing boat suitable for offshore work and able to proceed from one end of the coast to the other. She should also be fitted to stay out at sea for a week. This boat would be staffed with a crew competent to use Danish seines, ring seines and every other kind of gear suitable for taking migratory pelagic fish. She should also have a tender which can work the shallow waters and the mangrove creeks. Working hand in hand with this fishing craft would be a small base station and a fish curing officer. His main work would be to find out the best economic ways to produce a fish product which is hygienic, has good keeping qualities, and would meet all requirements of the employers of labour, and also the medical department. He would also test out the best methods of smoking, canning and the production of a fish product which would meet a high-class trade. This side of the investigation is as important as catching the fish. It is no use catching fish if you can do nothing with them.

The fundamental research should also have a suitable craft, properly fitted for its job and manned by the required scientific officers. The fitting and the work of such a craft is not within the limits of this article.

In conclusion it may be said that slow but substantial development is taking place with the native fishery and the native fishermen are beginning to react to the advice and help given to them. The best ways and means of developing the open water fishing beyond the reach of the native fisherman, by means of commercial exploitation, are not yet settled and require further investigation.

REVIEWS

BULLETIN ON NARCOTICS.—*Published quarterly by United Nations, Lake Success. Obtainable from agents for U.N. publications. Price $2 per year.*

This bulletin, the first issue of which appeared in October, 1949, is designed to present current reports on the control of narcotics. It will contain technical and scientific studies on narcotic drugs, articles on legislation and administration, and a bibliography of current works on the subject. Separate English and French editions will be published, and summaries of important articles will be available in Chinese, Russian and Spanish.

Steps are now being taken to simplify the international control machinery and replace the existing international instruments by a single convention. Future bulletins will give an account of progress in this field.

The first number of the bulletin contains illustrated articles on Opium Production throughout the World, The Commission of Inquiry on the Coca Leaf, Determining the Origin of Opium, and reports on recent meetings of the Commission on Narcotic Drugs and the United Nations Economic and Social Council.

The Bulletin on Narcotics will provide information on one of the vital subjects of the day for doctors, scientists and students of international affairs.

"TURKEYS AND GEESE" *by Herbert Howes.—Macmillan and Co., Ltd., St. Martins St., London. Price 6s.*

This is a practical guide for the poultry-keeper, farmer or smallholder who wishes to keep turkeys and geese. Although it is written for farmers in the United Kingdom, the basic principles should apply in East Africa. The author, who is Assistant Director of the National Institute of Poultry Husbandry, has kept constantly in view the needs of the practical poultry-keeper and has maintained throughout a simplicity of style and explanation.

Turkeys and geese are dealt with in separate sections under the headings, breeds and crosses, housing and management, natural and artificial incubation, brooding and rearing, feeding, preparation for marketing, and the treatment and prevention of disease. Numerous photographs have been included.

The book should do much to encourage the increased raising of turkeys and geese, since lack of information in the past has no doubt deterred some farmers from adopting this sideline.

THE CONSTRUCTION OF PNEUMATIC-TYRED VEHICLES ON THE FARM

By C. G. Clegg, Agricultural Officer, Tanganyika

(*Received for publication on 27th January,* 1950)

The many advantages and economies that are claimed for pneumatic farm equipment have been fully tested and satisfactorily proved under varying conditions in all parts of the world, both by experiment and by practical use. Most of these advantages are too apparent to be tabulated here and reference may be made to a note in this journal, Vol. IV, 1938, No. 2, page 112.

Under the peculiar conditions of East Africa some of these advantages are important from the erosion point of view. Wear and tear on farm roads with the subsequent gullying, when wood and iron-rimmed wheels are used, are greatly reduced, especially during the rains. The heavy haulage of grain, manure and the like on cultivated land is not only greatly facilitated but the likely damage from erosion is minimized. The three "home-made" pneumatic-tyred vehicles described in this note were constructed on an agricultural department farm just before the war and have done good service, the wagon still being in use.

(1) Small Farm Cart:

Frame of timber with corrugated iron sheeting. For this cart two oxen are used, though it is possible, with a well-trained animal, to use only one. It has, however, been found in practice that animals working in pairs are more satisfactory. For a cart such as the one described below only one boy is necessary, for when the same animals are in daily use, it is possible to dispense with a "leader".

Details of Construction.

The pneumatic equipment consists of a Dunlop C.A.V. conversion set, i.e. a steel axle 2 in. square by 60 in. long, steel artillery wheels 4 in. by 19 in., complete with tyres and tubes. (*Note*: There have been some minor changes in the post-war equipment such as the addition of a brake-operating mechanism and pressed steel spoke discs similar to those fitted for British cars).

The Frame.—A length of 4 in. by 4 in. timber is countersunk into the axle and held in position by two U-shaped clamps. Across the top of this are fixed, by means of flat iron angle brackets, three 6 ft. lengths of 4 in. by 2 in. timber. Into the latter are mortised six 3 in. by 3 in. uprights, each 2 ft. long, one at each end and one in the middle of each side. These are further strengthened by screwing on flat iron angle brackets to the uprights and transverse runners. Tie pieces of 2 in. by 2 in. are affixed along the tops of the runners.

The Body.—This is of corrugated iron sheeting and is nailed, with washers, to the bottom, sides and front. An upwards sliding door of corrugated iron on a light frame fits into the back. The dissel boom is of bush timber 8 ft. long, held between two bent lengths of flat iron and affixed to the under carriage.

(2) Farm Water Cart: (Capacity 80 gallons).

Two oxen are used and it is advisable in this case to have a leader. The pneumatic equipment is the same as for the cart. It is suggested however that, in order to cut down the cost in both types, and if available on the scrap heap, the axle and wheels from an old lorry or car be used.

A length of 6 in. by 4 in. timber is similarly countersunk into the axle and clamped into position. Two pieces of 6 in. by 4 in. by 3½ ft. timber are secured lengthwise at the ends of the axle beam and across these at each end and the middle is bolted a length of timber 5 in. by 4 in. by 4½ ft. Flat iron angle brackets and bolts are used throughout. Two well cleaned forty-gallon drums are placed side by side lengthwise to the axle and securely strapped to the frame by strips of hoop iron. Square holes are cut out in the tops of the drums and wooden tin-lined funnels are screwed on to the bent up edges of the holes. Either taps or wooden bungs may be used at the outlets.

(3) FARM WAGON:

This type of vehicle with variations or improvements in construction may be profitably used if an old chassis is available or can be cheaply purchased. The chassis complete with wheels, tyres, brakes and steering is all that is required. It has been found that the ease and control of steering, especially where there are sharp turnings, is of great advantage, while the use of an immediate brake action lessens the possibility of injury to the rear animals.

The Frame.—The steering column is loosened, reversed in position and cut down in length to some 8 inches. By doing this the available chassis length is increased from 8½ to 12½ ft. A 12½ ft. length of 5 in. by 3 in. timber is laid along the top of each side of the chassis frame, having been previously cut to fit. At equal distances apart six 5 in. by 3 in. beams are placed across them. 12 in. bolts secure both the beams, runners and the chassis and are countersunk into the beams. A 6 ft. carpenters' cramp is required in order that the 12½ ft. runners lie correctly along the curve of the chassis when the timber is being bolted into position. 3 in. by 3 in. by 3½ ft. uprights are mortised into the ends or the cross-beams and strengthened with flat iron angle brackets and with 2 in. by 3 in. timber struts.

The Body.—This is of corrugated iron and is nailed with washers to the bottom, sides and front end. A window may be cut out of the front end behind the driver's head. If required, a 9 in. by 1 in. board is used for the driver's seat and a protective head roof, though not essential, may be added. The brake rod is lengthened and is conveniently pivoted at the cross member. Wooden blocks are cut out and lightly held between the chassis and front springs to minimize any danger of spring damage.

It may well be found to be more convenient, and cheaper, to decrease the height of the corrugated iron sides and to add light removable uprights which are held in position by brackets, such uprights being higher than the corrugated iron sides. This alteration gives the advantage of being able to carry a greater volume of light loads such as maize stalks, etc. When heavy loads such as manure are carried, the uprights can be removed.

Approximate costings (on post-war basis)

	Sh.
Type (1) C.A.V. Conversion set (post-war type)	700
Timber	25
Flat iron, screws, nails, etc.	15
Labour	30
Sh.	770
Type (2) C.A.V. Conversion set	700
Timber	35
2 40-gallon drums	100
Flat iron, screws, nails, etc.	10
Labour	50
Sh.	895
Type (3) Old lorry chassis	500 — 700
Timber	80
C.I. sheeting (5½ lengths)	90
Flat iron, screws, nails, etc.	35
Labour	50
Sh.	755 — 955

In types (1) and (2), when the axle and wheels of an old car or lorry are used, the cost is reduced to approximately Sh. 320 and Sh. 365 respectivey.

Podocarpus timber is used throughout, costing between Sh. 3/50 and Sh. 5 per cubic foot. All timber is treated with Solignum. Construction can be carried out by a native carpenter and blacksmith assisted by unskilled labour.

The Kenya prices for a cart or wagon with solid 4 in. tyres are:—

	Sh.
Scotch farm cart	960
Large farm wagon, 1½ tons	1,450

SOIL EXAMINATION BY THE MICROPLOT TECHNIQUE

By R. V. Holme, Agronomist to A.E. & C.I. (East Africa), Ltd.

(*Received for publication on 5th December*, 1949)

Although there are still a number of farmers who think that the chemical analysis of their soil will determine what fertilizer it requires, it is nowadays fully realized by the agricultural scientist, not excluding the soil chemist himself, that comprehensive field experimentation is the most reliable method of solving the farmers' problems. By this method, the farmer's crop is treated in the farmer's field with various treatments laid out in such a way that statistical proof of the accuracy of the experiment can be provided. Increase or decrease of crop yield can be measured, and the probability that a similar result can be repeated under similar conditions can also be forecast.

However, normal field experimentation suffers from certain disadvantages. As field conditions cannot be reproduced accurately in different seasons or localities, it is not possible to know without long experimental experience in a particular area how far the results of a single experiment may be expected to be repeated in a different field or in a different season. The obvious way to overcome such a difficulty is to replicate each type of experiment many times in the same season, and to repeat this process for many seasons. This has been done in the United Kingdom and many of the older countries, in which considerable knowledge of fertilizer responses exists. As a result of this the use of fertilizers is so firmly established that a world wide shortage exists at the present time.

If large areas show similar responses for several seasons it becomes possible to generalize as a result of the experiments conducted, and to advise farmers as to which treatment to adopt. Where there is not sufficient agreement, not only qualitatively but also quantitatively, between different experiments, then it is obvious that the experiments must cover the area more thickly before reliable recommendations can be made.

There are many difficulties in the way of an extended field experimental service, not the least of which is the cost of it. The hazards of bringing an experiment through to harvest are in some cases severe, and experiments that have to be discarded before harvest from one cause or another rarely number less than ten per cent of the whole, and this figure may be greatly exceeded under difficult circumstances.

The problem of choosing sites which are representative of an area is also difficult. For obvious reasons it is always the desire of the experimentalist that his experimental area should be as uniform as possible. In choosing such sites very much land is precluded from experimentation from the outset, owing to its variable nature. For instance, land with the minimum slope is usually chosen, and land subdivided by gullies or anthills is avoided wherever possible. In fact, only when the scientist comes to choose sites for his experiments does he realize how much land is unsuitable for the purpose. Yet this same land will be farmed and the results from experimental areas will be applied to it.

For these, and other reasons, the soil scientist has cast around for rapid and reliable methods of comparing one soil with another so as to be able to recommend to the farmer what treatment he should give his land for different crops. Many methods have been adopted. Chemical soil analysis is the oldest established method. The very fact that it has been established since fertilezers were first introduced and yet changes in technique are continually being made, indicates that the soil chemist himself is not completely satisfied with the methods evolved.

More recently other methods have been introduced. The Mitcherlich method, the Neubauer method, the method of plant tissue analysis, the method of plant injection, etc., are some examples of methods of soil analysis in its broadest senses.

Whatever method is used to study the soil, the information obtained can only be a measure of the factors involved in producing the soil reactions at the time that the test is made. Changes may and do occur in the soil after a test is made. The ability of the plant to extract nutrients from the soil varies. The depth of sampling of the soil is frequently arbitrarily chosen, and may not be in accord with the depth of soil used by the plant. It must be realized therefore that all methods of soil testing have their limitations in one direction or another.

The soil is a dark problem and each new method of studying it casts light on a hitherto dimly seen side of the subject, but each method also relegates to comparative shadow other facets which require attention. It cannot be right therefore, to condemn one method as useless and to claim another method as reliable. The greater the number of methods which can be used to study the soil, the more diffuse will be the light thrown on the problem and the less dense the shadows of uncertainty. However, costs normally impose a limit to research work and it is therefore necessary to consider the cost of a method of soil study in relation to the knowledge gained from it. Unfortunately many modern methods need expensive capital equipment or great technical skill, both of which necessarily limit the scope of the work.

The microplot technique has been evolved in order to overcome these last two difficulties. It requires no expensive capital equipment nor a degree of skill which is not easily obtained.

Under certain circumstances it may have advantages over other methods, while in other circumstances the disadvantages inherent in the method may make it unsuitable. If, however, it is looked upon as a method of soil testing which helps to cast one more ray of light on a dark subject, and if it is considered as but one of the stepping stones in the study of soils, it should help in establishing the reaction of the soil to human treatment and the response of crops to such reaction.

The essential features of the microplot technique are its simplicity and the fact that it is carried out in the field under farming conditions. The area over which it can be applied is limited only by the number of people who will carry out its details with reasonable care. Its object is to test what reaction is obtained from soil treatments by a test plant grown for a few weeks in the field under normal seeding or planting conditions. By carrying out a number of microplots in an area much preliminary information can be obtained.

In a new district what fertilizers need to be tested? Do the soils vary so as to give markedly different responses in different areas, and if so, how can those areas be delineated? If any particular fertilizers are of major importance is there a strong interaction between them? It may be more important to study different levels of the most deficient ones, than to study all the fertilizers in less detail. Should the fertilizer be placed at any particular depth or distance in relation to the seed? Will germination be impaired? If so under what conditions? The answers to these questions and many more are frequently assumed in laying out a field experiment. Many of them have to be assumed or the experiment would become quite unwieldy. It may be said that although these factors are assumed in the first place they can be the subject of subsequent experiment. But this will take several years and in the meantime the questions posed by an inquiring mind mount unceasingly. By means of rapidly conducted microplots, on the other hand, the probable answers to these questions are indicated. Major experiments can then be planned along the lines which are most likely to lead to speedy results.

Some experimentalists maintain that normal commercial practice should be followed, and in default of precise information this is of course the only thing to be done. The dangers of such a system, if system it may be called, are however well illustrated by a recent case. A large series of field experiments were planned and fertilized at the normal depth adopted in the district. The depth naturally varied slightly according to soil and other conditions. A microplot experiment was laid down, after the rush of planting was over, to determine the effect of burying the fertilizer as against placing it on the surface. The effect of burying it was very large indeed, which indicated that the importance of this detail was far greater than was at first suspected. It is probable that in most of the major trials the fertilizer was buried at a suitable depth, but it is possible that too shallow an application of the fertilizer might account for some of the anomalous results obtained.

Microplot experiments may be classified according to whether a standard layout is used as for normal N, P, K, Ca experiments or whether a special layout is required by the circumstances. The adaptation of the standard microplot is a question for the individual experimentalist and the standard technique only need be described here.

The layout found most satisfactory is the 3^3 or 3^4 factorial plan as this not only gives plenty of replication for studying the main effects of any of the individual fertilizers, but also sufficient replication to decide whether first order interactions are of importance or not. The area taken up by the 81 plots of a 3^4 experiment is 34 feet square. After the land has been cultivated, this area is chained off and thin pegs placed at two-foot intervals each way. In this way nine rows and nine columns of two-foot-square plots will be obtained each separated from its neighbour by a two-foot pathway. In each of these plots three drills are made three inches deep. The fertilizers required for each plot are measured out in the field by means of carefully made standard measures, shaken up in a cigarette tin and applied in the bottom of the furrows. The fertilizer is lightly covered and 15 seeds of a quick growing plant are sown in each row. The drills are then finally covered over. At a suitably early stage the plots are thinned out to 30 plants per plot. After a standard number of weeks, four to six, according to temperature, when the plot weight will average at least 1 lb., the plants from each plot are pulled up, shaken free of earth, counted and weighed green in the field.

The calculations are based on the weight per 100 plants per plot and the results are given as a percentage of the applicable control figures. Statistical analysis is usually unnecessary, for the soil deficiency is measured by the magnitude of the response to a standard quantity of a particular fertilizer. Where the magnitude of a response is small, significance is in doubt, but the importance of the application of the fertilizer is small. As the response increases in magnitude so the economic importance of the fertilizer increases, but the significance of the figures becomes obvious and a formal test of significance is usually unnecessary.

The case here is rather different from many other types of experiment where dosages of fertilizer are chosen around the probable economic limit. In such a case it is desired to know whether one dressing is significantly more productive than another. In the case of the microplot, on the other hand, the dressings of fertilizer are kept constant from soil to soil. The index of soil fertility is the relative response of the standard test plant to these standard dressings. Three rates of fertilizer application are chosen since this allows a study of the response curve of the fertilizer. Since it is not difficult to get several hundred microplots done in an area, the study of response curves from adequate data is greatly facilitated. A very close correlation has been shown in the West Indies between the response curve due to nitrogen obtained from corn microplots and mature cane experiments.

Plots of two feet square are a convenient size at planting time and are also convenient before harvest for getting a general visual impression.

Suitable indicator plants are maize or white sunflower. They both exaggerate the effect of nitrogen and phosphate in relation to the responses to be expected from many crops taken to maturity. This exaggeration is most desirable since it magnifies the scale of comparison between the microplot and the commercial crop. It must of course be remembered that microplot values only give a scale which must be correlated with any particular commercial crop before that scale can be applied. Microplots, are not, however, so sensitive towards potash. While they will indicate soils where potash deficiency is fairly severe, some doubt may remain in the case of borderline soils.

Both white sunflower and maize are very suitable in other respects. Their planting is easily supervised since they are readily seen on the soil surface. They grow rapidly in the early stages and can attain a height of three feet in four weeks under ideal conditions. Of the two sunflower is preferable since it is less liable to injury from pests, etc.

It is interesting at this point to consider the points of divergence between pot tests and microplots, two very similar systems.

In the case of pot tests, detailed work is done with great accuracy. Standardization of procedure is taken to the point where the conditions are necessarily artificial. Such exactitude is vital for the study of certain aspects of soil science, but the interpretation of the data to field conditions must be done with circumspection. Scientifically trained staff are necessary for these tests, and the carefully controlled conditions necessary can only be obtained at a specialized centre for the work, where laboratory facilities are available. The tests, however, are not dependent on the weather, since the pots are protected from rain, etc., and watering is done by hand.

Microplot tests on the other hand, are carried out in the field during the planting weather when field crops are normally sown. A gang of ordinary labourers can readily be trained to carry them out under the supervision of an educated person, who is capable of seeing that reasonable standards of accuracy are maintained. An average microplot experiment can be laid down in an hour by a gang of half a dozen labourers who are used to the work.

Microplot tests are therefore suitable as a follow-on to pot tests. The results obtained by the latter can be checked cheaply under a wide range of farming conditions by means of these small scale field experiments. The best way of applying the knowledge gained by pot tests can be worked out by means of microplots, and finally large scale field trials of reasonable size can be used to obtain the answers in the language the farmer best understands.

A SPRAY TUNNEL FOR CATTLE

By R. R. Le G. Worsley, Biochemist, East African Veterinary Research Organization, Kabete, Kenya

(*Received for publication on* 11*th February*, 1950)

Spray tunnels for cattle, as alternatives to dips, are in use on several farms in Kenya.. They are considerably cheaper to build than dips, costing half or even less, and only a fraction of the amount of dip wash need be made up at one time. They are thus much more economical than dips when only comparatively few cattle have to be treated.

One objection raised against spraying is that it takes two to three times as long as dipping and that it is, therefore, only of use with small herds.

An experimental spray tunnel was constructed at Kabete, based on what appeared to be the best points of numerous ones visited. The piping, nozzles, etc., were made movable in order that different positions, size of nozzles, etc., could be tried. The spray tunnel consists of a stone crush with solid walls, with one or more rows of iron piping, containing nozzles, above and below where the cattle stand. Dip wash is pumped through the nozzles by means of a hand, or a mechanically driven, pump.

Spraying may be done either at high pressure using very fine nozzles or at low pressure using fairly coarse nozzles. The former requires a much more powerful and, therefore, expensive pump, and blockage of the nozzles with small solid particles is much more likely: constant supervision would be required if effective spraying were to be carried out. Low-pressure spraying can be done with a hand pump, or a small motor-driven one, and as the nozzles are comparatively large, they do not easily become blocked. This method has therefore been adopted.

The main points to decide were the size and type of nozzle to use, the distance apart of the nozzles, and whether to use a single row centrally placed or two rows obliquely placed.

Several nozzles were tried, but by far the best results were obtained with adapted watering-can roses. These were made locally from galvanized iron sheet, and a number of holes 3/32 of an inch in diameter were drilled in them: this size of hole was found to be the most satisfactory. At first, too many holes were made causing too big a drop in pressure: trial showed that about 17 holes per nozzle were sufficient.

This type of nozzle placed at intervals of two feet gave complete cover on cattle. Trials showed that a single row of nozzles beneath the animals was sufficient to give complete wetting of the belly and all under parts, but that two rows of nozzles placed obliquely above the animals gave better wetting of the back than one central row.

Complete wetting of all parts of the cattle except inside the ears is obtained by this spray. If hand dressing is carried out after spraying, this is sufficient, but if hand dressing is not done, then a small jet-type nozzle, with a tap on it for preference, connected to the pumping system by means of a length of hose piping, must be provided so that a jet of the dip wash may be directed into each ear. Ordinary hand dressing is, however, preferable.

Two concrete tanks, each of about 400 gallons capacity are sunk in the floor of the pump house, which is built alongside the spraying tunnel. The dip wash is pumped from the second of these tanks through the nozzles on to the cattle: the excess wash runs off and returns through channels in the floor to the first tank, where it passes through a fine wire gauze tray filter, to remove solid particles. When the wash reaches a certain height in this tank, it overflows into the second tank, passing through another similar tray filter: from here it is repumped through the nozzles. The same wash is thus in continuous circulation.

For a herd of 100 or 200 animals, about 500 gallons of wash are sufficient: if a larger number of cattle is sprayed it would be advisable to build larger concrete tanks and to use more dip wash.

A small motor-driven pump is the most convenient means of spraying, but a hand pump is quite satisfactory, provided the operator does not get tired and allow the pressure to drop. It is necessary to circulate wash at the rate of about 600 gallons per hour at a pressure of 10 to 20 lb. per square inch.

Tests have shown that, with the nozzles and layout described in this paper, cattle can be thoroughly and satisfactorily wetted in about 20 seconds. This is only slightly longer than the time taken in dipping.

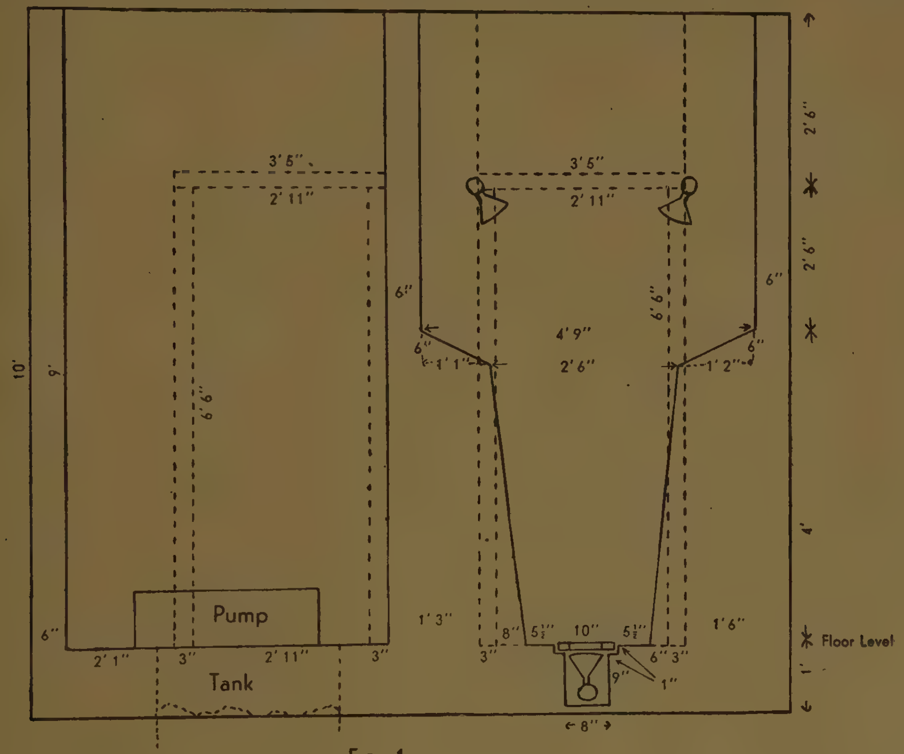
3' 5"
2' 11"
6' 6"
10'
9'
6"
Pump
2' 1"
3"
2' 11"
3"
Tank
1' 3"
6"
6"
1' 1"
3' 5"
2' 11"
4' 9"
2' 6"
6' 6"
1' 2"
6"
6"
2' 6"
2' 6"
4'
1'
Floor Level
1' 6"
8"
5½"
10"
5½"
3"
6"
3"
9"
1"
8"

FIG. 1

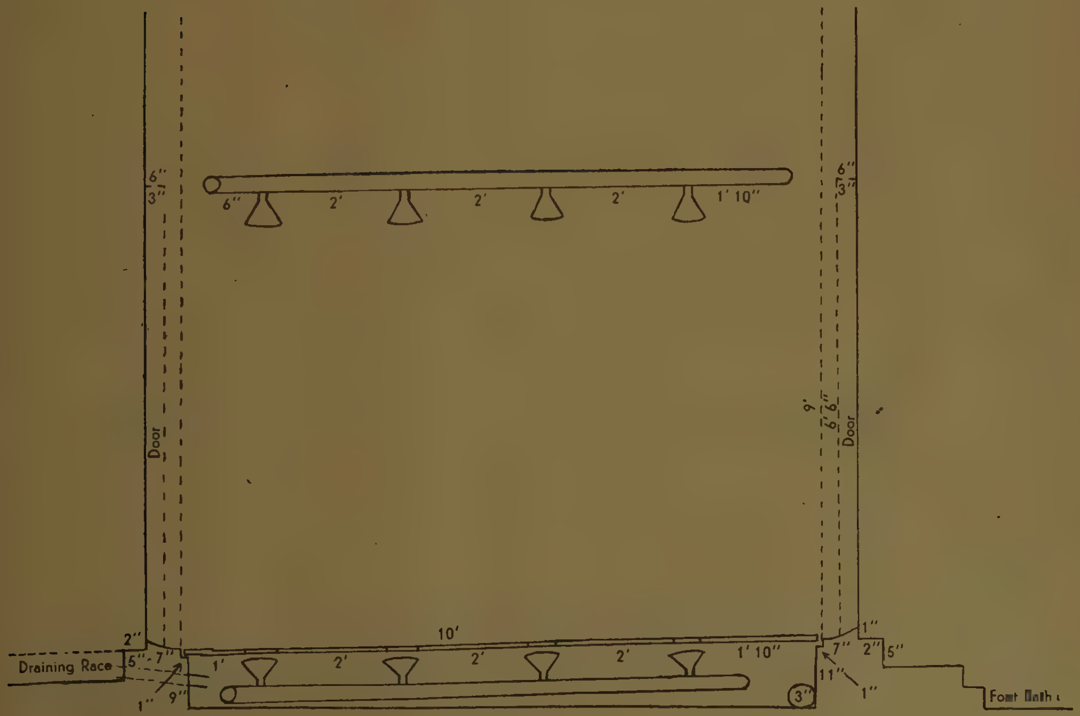
6"
3"
6"
2'
2'
2'
1' 10"
6"
3"
Door
9'
6' 6"
Door
10'
2"
Draining Race
5"
7"
1"
9"
1'
2'
2'
2'
1' 10"
3"
7"
2"
5"
1"
11"
1"
Foot Bath

FIG. 2

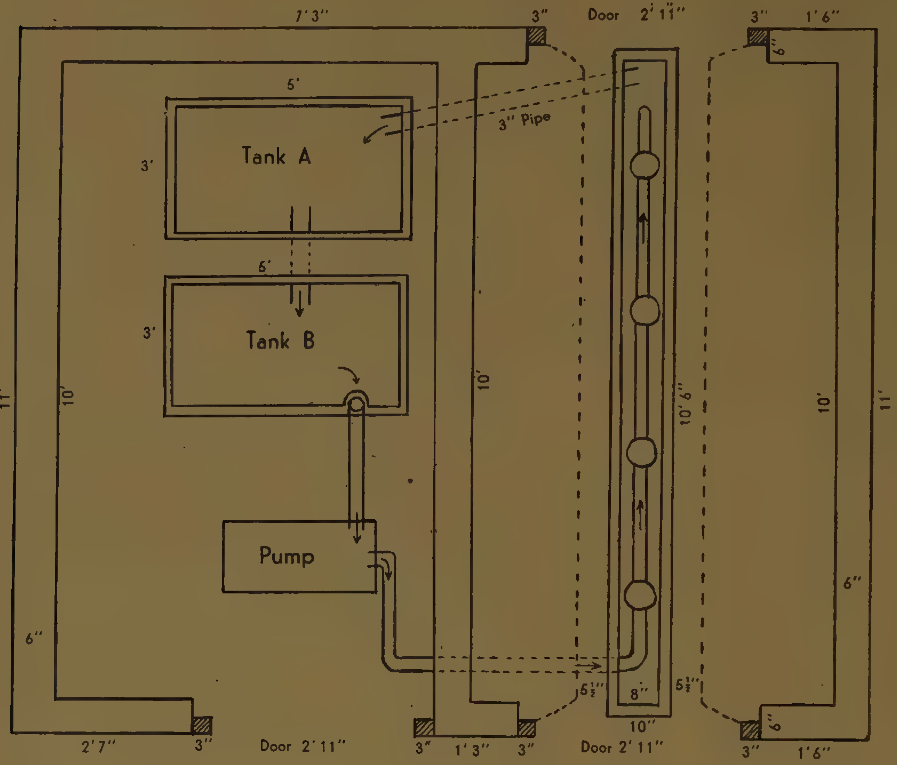
7'3"
3"
Door 2' 11"
3"
1'6"
5'
3" Pipe
3'
Tank A
5'
3'
Tank B
11'
10'
10'
10' 6"
10'
11'
Pump
6"
6"
6"
6"
5½"
8"
5½"
10"
2'7"
3"
Door 2' 11"
3"
1' 3"
3"
Door 2' 11"
3"
1'6"

FIG. 3

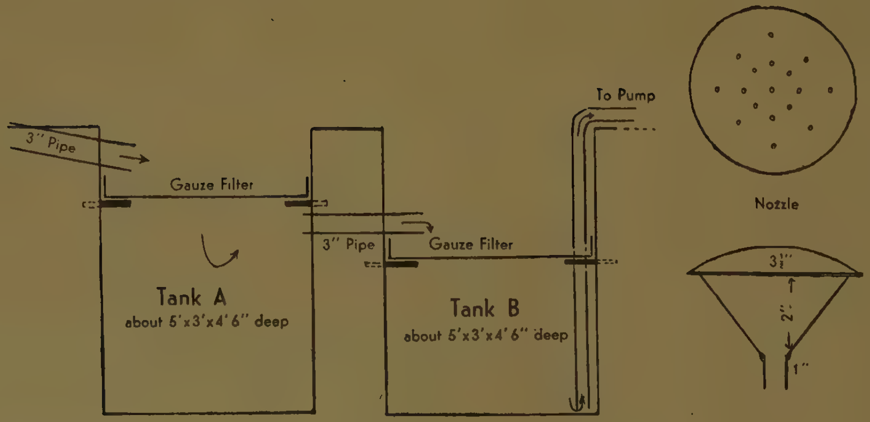
3" Pipe
Gauze Filter
Tank A
about 5'x3'x4'6" deep
3" Pipe
Gauze Filter
Tank B
about 5'x3'x4'6" deep
To Pump
Nozzle
3½"
2"
1"

FIG. 4

Benzene hexachloride (gammexane) dip washes are particularly suited for spraying, since only about 500 gallons are made up at a time and the tank can therefore be emptied and cleaned out at fairly frequent intervals, say every six to eight weeks, and fresh wash put in: B.H.C. washes are more effective when freshly made up. If a suspension-type dip is used, means of keeping it stirred up in the tank must be provided, as otherwise it will tend to settle to the bottom. Washes are used at the same dilution as for dipping.

The drawings and descriptions show how the spray tunnel is to be constructed. It may be built of concrete, or of stone or brick, cement-lined inside. It is essential that the spray tunnel itself should be strongly built so as to withstand kicking by the cattle. The bottom row of nozzles is placed in a channel sunk beneath the floor level and a stout wooden plank or cement slabs, used to cover them: the spray comes up through round holes in the plank or slabs, and these holes must not be large enough to allow cattle to put their feet through them and damage the nozzles.

The excess wash runs into this channel and returns to the first tank through a three-inch pipe. A piece of three-inch pipe also connects the two tanks. Two-inch piping was used throughout the supply system, except for the nozzles, which were on one-inch piping. A pipe connects the draining race to the spray tunnel so that wash draining from the cattle can return to the tank. Means of closing this when spraying is not in progress must be provided to prevent rain-water entering.

A foot bath should be provided at the entrance and it should be cleaned out regularly: this will keep down the amount of solids entering the tank and help to minimize any blocking of the spraying system.

Fig. 1 shows an elevation of the tunnel and the pump house, viewed from the end: the dotted lines indicate the position of the doors, and of the concrete tanks. Fig. 2 shows an elevation of the tunnel, viewed from the side: dotted lines showing the doors and end walls. Fig. 3 shows a ground plan of both tunnel and pump house. Fig. 4 shows a side view of the tanks and filters and a side and top view of one nozzle. The gauze filter in the first tank is placed immediately below the inlet pipe coming from the bottom of the spraying tunnel: the slope of this three-inch pipe should be just sufficient to allow the wash to run freely. The filter is supported on iron rods let into the sides of the tank. Immediately below this filter a piece of three-inch pipe connects to the second tank and another filter is placed just below the outlet of this pipe. The wash thus has to pass through both filters: the suction pipe from the pump draws wash from below the second filter.

The exit door from the tunnel should be made in two horizontal sections so that the upper half may be opened whilst the lower half remains shut: the division should be at such a height that the animal's ears may be sprayed by the operator when standing outside.

The description of the spray tunnel is given in response to numerous requests for a suitable design. The tunnel has only just been completed and there has not yet been time to determine how effective it is when used over a long period. It has so far proved to be an effective tunnel for spraying the whole animal within a reasonable time. Its construction is relatively simple and it should not be difficult to keep in working order.

THE BULB EELWORM DISEASE OF NARCISSUS IN KENYA

By R. M. Nattrass, Department of Agriculture, Kenya

(*Received for publication on 10th February, 1950*)

The Bulb Eelworm disease of *Narcissus* species has long been the cause of serious loss to commercial growers of these plants in Europe. It has only recently (1949) been recorded in Kenya. In appearance the disease symptoms are similar to those usually associated with fungi or bacteria. It is, however, caused by an eelworm *Anguillulina dipsaci.* This is quite distinct from the Root Knot eelworm *Hederodera marioni* which causes swellings on the roots of a large range of plants and with which most gardeners are only too familiar.

Where, in a bed of *Narcissi,* dwarfed plants with yellow distorted foliage occur, the Bulb Eelworm may be suspected. A definite indication of the disease is the presence of brown concentric rings of dead tissue seen when an affected bulb is cut horizontally.

On the foliage of the affected plants may be found small oval swellings of a paler colour than the surrounding green of the leaf. They can readily be felt when the leaf is drawn through the finger and thumb. The epidermis over these swellings may split and the underlying tissue dry out, leaving brown areas.

The eelworms are too small to be seen without the aid of a lens, being, when fully grown, about 1/20th of an inch in length. They enter the growing plant through the soft tissue of the neck, as they are unable to penetrate the hard outer scales or the basal plate of the bulb. Being also unable, for a time, to penetrate the membraneous outer walls of the scales, they are confined to the particular scale entered. Here they live and multiply, working round inside the scale and leaving a band of dead tissue behind them. This results in the formation of the characteristic concentric rings. The affected bulbs ultimately die but this may take more than one season.

If an affected bulb is in active growth, the eelworms are carried up with the developing foliage and there produce the characteristic swellings. When the foliage withers at the end of the season, the eelworms remain inactive but are released in the soil and regain their activity when the foliage becomes moist and decays.

Bulbs with only some of the scales invaded produce dwarfed plants with the characteristic yellow and distorted leaves and flower stalks. In stored bulbs the eelworms do not spread from bulb to bulb but they continue to multiply and destroy those already invaded.

In clean land distant from any infected bulbs the disease will only appear if introduced with infected planting material or contaminated soil. In light, well drained soil, the spread from bulb to bulb is relatively slow, so that an infected patch will extend slowly. In damper and heavier soils the spread will be more rapid and will be assisted by the transport of contaminated soil by cultivation, the use of tools, and by the feet of workers, all of which may start up new foci of infection. The parasites may also be spread by the movement of surface water. A particular danger is the spreading of infection by means of the dried foliage.

As the growing of narcissus and daffodils in Kenya is as yet on a comparatively small scale, any outbreak should be dealt with by the immediate eradication of the whole stock. Anyone who suspects the presence of the disease should take steps to have it confirmed. Only prompt measures taken to deal with isolated outbreaks will prevent the eventual spread of the disease by the distribution of infected material.

The eradication must be complete, all the bulbs and any fallen foliage must be collected and, preferably, burnt. Since a number of eelworms will inevitably have found their way into the soil, at least 18 months should elapse before *Narcissus* species are again planted.

The bulb eelworm attacks a number of different plants, but fortunately there are various biological strains, each of which is confined to a narrow range of host species. It is safe to plant up with another crop, but not with onions or strawberries, both of which are susceptible to attack by the *Narcissus* strain. Certain weeds are also attacked, particularly species of *Plantago.* The ground must, of course, be kept clean of these during the starvation period.

The hot water treatment, whereby the eelworms are killed in the dormant bulbs, is practised by commercial growers in Europe and America. It consists of immersing the bulbs for three hours in water maintained at a temperature of 110° F.

It is not suggested that this should be undertaken by the small grower in an attempt to eradicate the disease, but it might be worthwhile to treat any bulbs which have been newly purchased or acquired. If this is not possible, it would be a wise precaution to plant them in isolation some distance from the garden until it is certain that the bulbs are free from eelworm.

The informtion given in this note is largely drawn from Bulletin No. 51 of the Ministry of Agriculture and Fisheries, to which the reader is referred for a fuller account of the disease and its treatment.

I am indebted to Mr. W. C. Moore, Director of Plant Pathological Laboratory of the Ministry of Agriculture and Fisheries, and to Dr. T. Goodey, Head of the Nematology Department, Rothamsted Experimental Station, for the identification of *A. dipsaci* on the Kenya material.

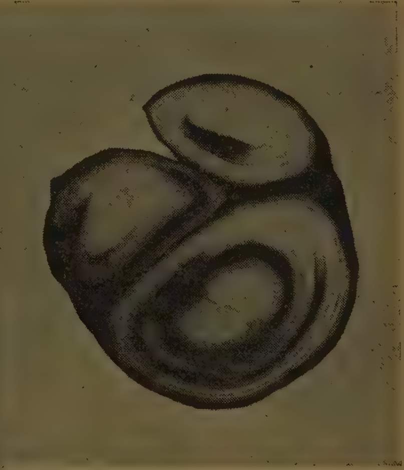

FIG. 2—Cross-section of diseased bulb showing affected scales.

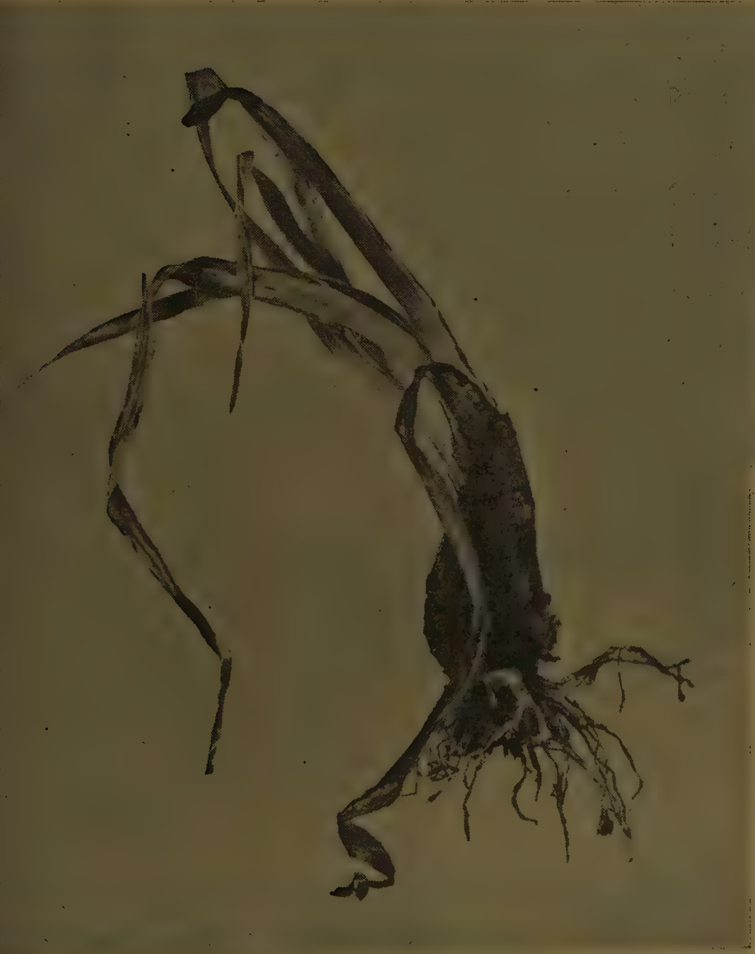

FIG. 1—*Narcissus*—plant attacked by the Bulb Eelworm.

LOOSE SMUT OF WHEAT

By R. M. Nattrass, Department of Agriculture, Kenya

(*Received for publication on 25th January, 1950*)

Loose Smut of wheat (*Ustilago tritici* (Pers.) Rostr.) is of comparatively rare occurrence in Kenya, but there is some indication that it may be on the increase.

The disease is easy to recognize in the crop as the smutted ears are already black when they emerge from the sheath. The spore masses are protected only by a thin membrane which quickly ruptures on emergence of the head, allowing the spores to be blown away. The bare blackened central stalks of the ears are characteristic of the disease.

The loose spores are carried by the wind among the crop at flowering time. Should the spores alight on the sticky, feathery stigmas of the wheat flower, they germinate and send down a germ tube which eventually reaches the young developing grain. Here the resulting mycelium remains in a dormant state but having no apparent harmful effect on the grain which is harvested along with the healthy grain.

When the infected grain is sown, the fungus inside it becomes active and occupies the region of the growing point. Here it moves up with the developing plant, still having no visible effect. Not until the ear begins to form is there any indication that all is not well with the plant. At this stage, the fungus bursts into activity, invading the whole of the ear and replacing the developing grains with fungus tissue which quickly turns black with the formation of quantities of spores. These are ready once more to infect the open flowers and so perpetuate the disease.

From the above it will be seen that the fungus is actually inside the wheat grain in the form of mycelium, not, as is the case with Covered Smut or Bunt, as spores attached to the outside of the grain. The grain contaminated with external spores can be effectively treated with fungicidal dips and dusts, but such treatment is, of course, useless where the grain is infected internally. For this reason the disease may appear after the seed has been treated with a fungicide. The only effective treatment for Loose Smut is one which will kill the fungus in the grain without injuring the grain itself. This can be done by means of the hot water treatment, whereby the grain is dipped for ten minutes in water hot enough to kill the fungus but not the grain. It is a troublesome process and needs careful adjustment of temperature which has to be kept within a narrow margin. The process is not an easy one for farmers to attempt. The best way to avoid the disease is to sow seed only from crops which are free from Loose Smut. As the disease cannot be detected in the seed, inspection of the growing crop is, of course, necessary.

This note on the life history and control of Loose Smut of wheat applies equally to Loose Smut of barley.

NOTE

The hot water treatment is done in the following way. The seed is put into a sack with enough space left to allow for swelling and the sack placed in cold water. It is lifted out two or three times to make sure that the water reaches all the grain and is then left in the water for four hours. After this, the sack is lifted out and allowed to drain. It is then submerged in water kept at a temperature of between 52° C. and 54° C. The temperature, which can be adjusted by the addition at intervals of boiling water, must be kept within this narrow range. If it rises above 54° C. the germination of the grain will be affected. If it falls below 52° C., the fungus will not be killed. Aften ten minutes at the required temperature, the grain is spread out in a thin layer. When dry, it is ready for sowing.

In the hot water treatment of barley, the seed, after four hours pre-soaking in cold water, is plunged for five minutes in water at 49° C. and then steeped for ten minutes at between 51° C. and 55° C.

LOOSE SMUT OF WHEAT

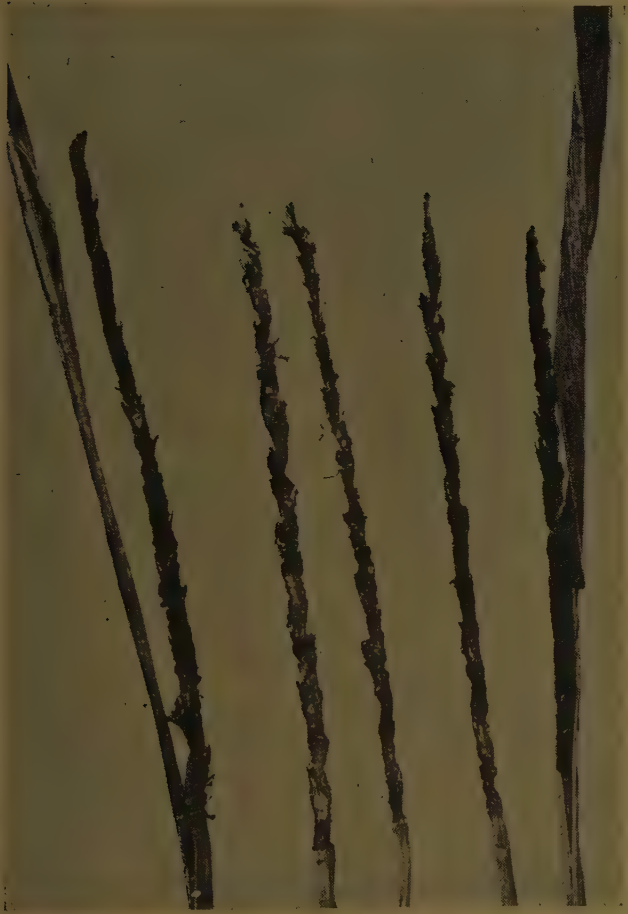

FIG. 1—Ears of wheat affected with Loose Smut.

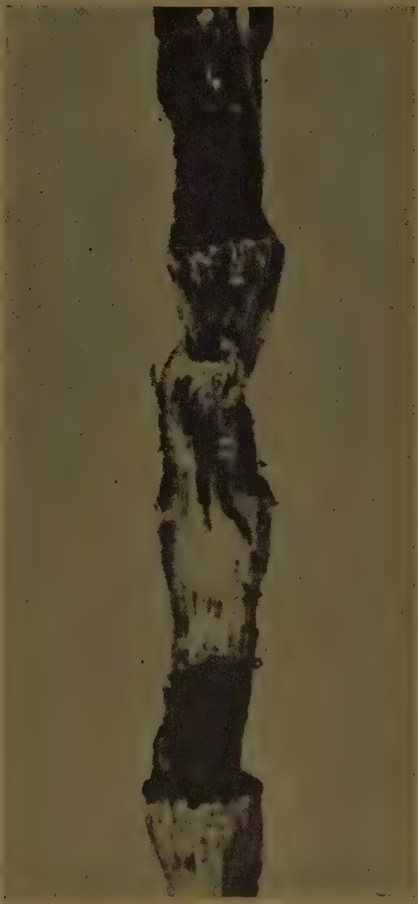

FIG. 2—Part of the central stalk of an affected wheat ear. Enlarged.

COLLOQUIUM ON GRASSLAND RESEARCH

[*Report on a meeting of the Specialist Committee on Grassland Research under the East African Advisory Council for Agriculture, Animal Industry, and Forestry, held in Nairobi on the 7th–8th December,* 1949.]

Members and Observers Present.—Dr. Keen, E.A.A.F.R.O. (elected chairman at the meeting), Messrs. Edwards, Faulkner, Bogdan and Sherwood (Kenya); Messrs. van Rensburg and Hutchison (Tanganyika); Messrs. Kerkham and Randall (Uganda); Mr. Briant (Zanzibar); Drs. Worthington, French, Glover and Duthie and Messrs. Fiennes, Todd and Ledger (Inter-territorial services); Dr. Eden and Mr. Carr (non-Government). Mr. Peat (Tanganyika) was unable to attend the meeting because of transport difficulties.

Dr. Keen (chairman) outlined the terms of reference of the Committee and the objects of the meeting. He emphasized that grassland research is only one facet of the problem of grassland utilization and animal husbandry and that meetings of this and other specialist committees would be conducted as scientific colloquia rather than as committee meetings. He pointed out that the East African Advisory Council had recommended that grassland research should be based on first-order territorial experimental stations, of which there should be at least one in each of the main ecological zones in East Africa. In view of this, the progress of the ecological survey is of the utmost importance, and therefore the present position and future plans of the ecological survey should be considered by the meeting. But as this and other long-range researches could not be completely implemented until facilities and staff became available, the Committee could profitably also consider possible amplifications of existing short-term researches and technological investigations, now being done in the territories.

Reviews of work on grassland and related subjects in Kenya, Tanganyika and Uganda were read and discussed: these papers are given in full below, and a summary of the discussion is given after each paper or group of papers.

PAPER I

TANGANYIKA WORK ON FODDER PLANTS AND GRAZING MANAGEMENT

By H. J. van Rensburg

A large number of fodder plants have been propagated at Mpwapwa as well as on many of the Native Authority demonstration farms and Agricultural Research Stations throughout the Territory, including Ukiriguru and Lubaga in the Lake Province.

Planting material for the Mpwapwa trial plots has been collected from practically all over the Territory and some species were imported from Kenya, Uganda, Nyasaland, Southern Rhodesia, South Africa, the Gold Coast, the United States of America, Brazil, Australia, Hawaii and Japan. This work was started by Staples in 1931 and since then over 300 different species and varieties of fodder plants have been propagated in the trial plots. A list of some of these is attached.

A very noticeable feature is that nearly all the exotic species have proved disappointing and after a brief spell of publicity most of them have faded out. They generally seem to do well when they are first planted and while they receive regular attention. A number of the indigenous plants which are suited to the local adverse conditions have proved most valuable. Some of these give excellent results under natural conditions in mixed pastures when properly managed though they do not always respond to cultivation and cannot be propagated easily.

It is found at Mpwapwa that with regular irrigation on soil which is manured and limed lucerne yields over 40 tons of green fodder per acre per year with six to nine cuttings, and Elephant grass under the same conditions yields over 100 tons per acre. For soilage purposes this grass gives better results than any of the other introductions most of which seem to be relatively short-lived. Some varieties of Elephant grass are very hairy and consequently unpleasant to handle. This characteristic presents a definite disadvantage but fortunately there are some relatively glabrous varieties and one of these selected by Thomas in Uganda is almost entirely free from hairs. This variety is being propagated at Mpwapwa and is doing well. The seedlings from these plants, however, are hairy and it seems that in order to maintain the glabrous variety vegetative propagation must be adhered to.

Setaria splendida and some varieties of *Setaria sphacelata* are also giving good results as soilage grasses but they are more delicate, require more attention, and give smaller yields. These have the advantage, however, of being more leafy; they are almost entirely hairless and easy to handle.

Under careful management these succulent grasses yield well and compare very favourably with other fodder plants including lucerne, both as regards palatability, protein and mineral content. It is, however, essential to use them while they are young and succulelnt because their feeding value deteriorates rapidly when they become stalky and fibrous.

Some of the annual crops, particularly cow peas, are most useful in field rotations, and grown together with maize produce excellent material for ensilage.

On studying the list of fodder plants which were introduced and established at Mpwapwa it is most striking that a very small percentage of the multitude of introductions have proved to create the impression that I object to the introduction of plants which are likely to be useful but I rather feel that the aspect of encouraging, improving and cultivating some of the species already in common use is being neglected and requires more attention. The following are most frequently used for fodder:—Cow peas, maize, Elephant grass, *Setaria splendida* and *Setaria sphacelata*.

Amongst the common grasses a large number of species plan an important role in mixed natural pastures in Tanganyika but they are by no means all suitable for propagation or easy to establish under artificial conditions. The more valuable species include:—

Cynodon plectostachyum;
Cenchrus ciliaris;
Bothriochloa insculpta;
Brachiaria brizantha;
Brachiaria serrifolia;
Chloris gayana;
Chloris virgata;
Chloris pycnothrix;
Dactyloctenium ægyptium;
Themeda triandra;
Acroceras macrum;
Andropogon schirensis;
Panicum maximum;
Pennisetum clandestinum;
Digitaria spp., and
Setaria spp.

There are many other species including annuals which form a valuable part of mixed grazing under natural conditions. A considerable amount of food is also obtained from browsing dicotyledonous plants particularly in the deciduous thicket vegetation. This latter source, however, is much inferior to a good grass-herb mixed pasture and thicket vegetation should wherever possible be transformed into grassland with scattered trees. Thicket-forming species do not only compete with the grasses for moisture and light but they also encourage the formation of footpaths which accelerate erosion. Further investigations are being initiated to establish the minimum amount of thicket growth that should be removed to obtain a satisfactory pasture.

Grazing Management

A barbed wire fence is still a novelty in most parts of Tanganyika and "grazing management" a meaningless term which is of no practical value in the wide open spaces. The existing condition is rather one of grazing mismanagement. The only controlling influences at present are natural forces such as poor distribution and lack of adequate water supplies and grazing, trypanosomiasis carried by tsetse flies, and the occurrence of other diseases.

The advantages of mixed grassland pastures, in which a number of palatable legumes and other dicotyledonous plants generally occur, was demonstrated very conclusively by Staples in a series of bush thicket and grassland experimental plots at Mpwapwa. The results were so striking that it was decided to terminate grazing in the bush thicket plots and to convert them into grassland with scattered trees to gather further information on the eradication of thicket vegetation and the carrying capacity of mixed grass pastures.

The grassland experiments have been continued on a modified basis and in general the conclusions derived at by Staples still hold good. Some of these are quoted here for convenient reference. (*Vide* The East African Agricultural Journal, Vol. XI, pp. 43–46, 1945.)

"(1) Pastures in which the woody vegetation was cleared and burned and woody regeneration weeded out, increased greatly in their carrying capacity while the distribution of the feed throughout the year is far more satisfactory than in the original bushland grazings.

(2) Grassland pastures, even when the herbage is predominantly annual species, can be grazed at intensities varying from three to one and a half acres per beast, either on a yearly or a deferred basis, and yet seem to give entirely satisfactory protection from run-off and erosion.

(3) Secondary bushland pastures grazed on a deferred basis, even at the low intensity of

a beast to 14 acres, showed obvious signs of run-off and sheet erosion with the ground largely bare (and devoid of feed) by the end of the dry season.

(4) The system of deferred grazing in which the pasture is not grazed during the second half of the growing season (March to June) has given excellent results under the grassland conditions in increasing the carrying capacity and both the quality and the quantity of feed available for dry season use. This treatment also appears to have encouraged the growth of perennial grasses most; these grasses provide not only more satisfactory dry season grazing than the annual species but also afford a better protective cover to the soil."

It is very fortunate that in many parts of semi-arid Tanganyika pastures maintain a fairly high level of feeding value and remain palatable throughout the dry season. During this period the protein and mineral contents of the matured grasses are probably considerably augmented by leaves and twigs of browse plants and by seed pods. It is however, essential that more emphasis should be put on the necessity for storing fodder supplies in areas where the dry season is long and likely to last for seven months or longer. Unfortunately work which entails the provision of dry-season fodder has to be done during the rains when activities in connexion with the production of grain crops are generally in full swing. This is also one of the reasons why grass planting is so often neglected. If seed supplies of suitable drought resistant species were more rapidly available pasture establishment would become a more feasible and practicable proposition even under conditions prevailing at present.

APPENDIX

A List of Some of the Plants Which Have Been Cultivated in the Fodder Trial Plots at Mpwapwa

Acacia albida; from Mpwapwa, Tanganyika.
Acacia aneura; from Australia.
Acacia giraffæ; from Southern Rhodesia.
Acacia spirocarpa; from Mpwapwa, Tanganiyka.
Achyranthes aspera; from Mpwapwa, Tanganyika.
Acroceras macrum (Nile grass); from Mufindi, Tanganyika.
Alysicarpus glumaceus; from Mpwapwa, Tanganyika.
Alysicarpus rugosus; from Nagpur, India.
Andropogon annualatus; from Nagpur, India.
Andropogon citriodora; from Mwanza, Tanganyika.
Andropogon contortus; from Dar es Salaam, Tanganyika.
Andropogon gayanus; from Southern Rhodesia.
Andropogon monticola; from Nagpur, India.
Andropogon pumilus; from Nagpur, India.
Andropogon pertusus; from Nagpur, India.
Andropogon purpureo-sericeus; from Nagpur, India.
Apluda varia; from Nagpur, India.
Atriplex sp. (salt bush); from Singida, Tanganyika.
Beckeropsis sp.; from Mpwapwa, Tanganyika.
Bothriochloa insculpta; from Mpwapwa, Tanganyika.
Bouteloua eriopoda; from United States of America.
Brachiaria brizantha; from Handeni, Tanganyika, and Uganda.
Brachiaria decumbens; from Uganda.
Brachiaria dictyomeura; from Southern Rhodesia.
Brachiaria distachya; from Dar es Salaam, Tanganyika.
Bromus catharticus; from Kenya.
Bromus marginatus; from Kenya.
Bromus inermis; from the United States of America.
Bromus uniloides (rescue grass); from Kenya.
Cadaba adenotricha; from Mpwapwa, Tanganyika.
Cajanus cajan (pigeon pea); from Mahenge, Tanganyika.
Canna edulis (edible canna); from Mbulu, Tanganyika.
Cenchrus ciliaris (African foxtail grass); from Mpwapwa, Tanganyika.
Ceratonia siliqua (carob tree); from South Africa.
Chloris gayana (Rhodes grass); from Rufiji, Tanganyika.
Chloris paraquayensis; from the United States of America.
Chloris spp.; from Ufipa, Tanganyika.
Cicer arietinum (Gram); from Mpwapwa, Tanganyika.
Chrysopogon sp.; from Shinyanga, Tanganyika.
Clitoria ternata; from Mpwapwa, Tanganyika.
Commiphora sp.; from Mpwapwa, Tanganyika.
Cortaderia argentea (pampas grass); from Kenya.
Crotalaria gremtiana; from United States of America.
Crotalaria oocarpa; from United States of America.
Crotalaria spirabilis; from United States of America.
Crotalaria quartiniana; from Mbulu, Tanganyika.
Crotalaria utura; from United States of America.
Crotalaria spp.; from Mpwapwa, Tanganyika.
Cynodon dactylon (lawn grass); from Mpwapwa, Tanganyika.
Cynodon plectostachyum (star grass); from different parts of Tanganyika and Uganda.
Dactyloctenium sp.; from Moshi, Tanganyika.
Desmodium triflorum; from South Africa.
Dicanthium papillosum; from Mpwapwa, Tanganyika.
Digitaria eriantha (finger grass); from Southern Rhodesia.
Digitaria exilis; from Gold Coast.
Digitaria marginata; from Mpwapwa, Tanganyika.
Digitaria maritima; from South Africa.
Digitaria milanjiana; from Dar es Salaam, Tanganyika.
Digitaria pentzii; from South Africa.
Digitaria pole-evansii; from South Africa.
Digitaria scalarum; from Njombe, Tanganyika.
Digitaria setivalva; from Shinyanga, Tanganyika.
Digitaria swazilandensis; from Southern Rhodesia.
Digitaria uniglumis; from Njombe, Tanganyika.
Disperma quadrisepalum; from Mpwapwa, Tanganyika.
Dolichos lab-lab (mfiwi); from Maswa, Tanganyika.
Echinochloa pyramidalis (antelope grass); from Dodoma, Tanganyika.

Eleusine indica (goose grass); from Uganda.
Eragrostis chloromelas; from South Africa.
Eragrostis congesta; from Njombe, Tanganyika.
Eragrostis curuula; from South Africa.
Eragrostis lehmaniana; from South Africa.
Eragrostis margaritacea; from Mpwâpwa, Tanganyika.
Euchlaena mexicana (Teosinte); from South Africa.
Ficus spp.; from Mpwapwa, Tanganyika.
Glycine javanica; from Mpwapwa, Tanganyika.
Hæmarthria fasiculata; from Southern Rhodesia.
Heteropogon contortus (spear grass); from Mpwapwa, Tanganyika.
Hyparrhenia barterii (thatch grass).
Hyparrhenia filipendula; from Uganda.
Hyparrhenia nyassæ; from Njombe, Tanganyika.
Hyparrhenia rufa; from Mpwapwa, Tanganyika.
Hyparrhenia ruprechtii; from Shinyanga, Tanganyika.
Hyparrhenia variabilis; from Mpwapwa, Tanganyika.
Indigofera arrecta; from Mpwapwa, Tanganyika.
Indigofera endecaphylla; from Mahenge, Tanganyika.
Indigofera linifolia; from Nagpur, India.
Indigofera retroflexa; from Mpwapwa, Tanganyika.
Indigofera suaveolens; from Mpwapwa, Tanganyika.
Ischæmum glaucostachyum; from S. Rhodesia.
Ischæmum laxum; from Nagpur, India.
Ischæmum sulcatum; from Nagpur, India.
Iseilema laxum; from Nagpur, India.
Leersia hexandra; from Dodoma, Tanganyika.
Leptochloa obtusiflora; from Moshi, Tanganyika.
Lespedeza (Kobe); from United States of America.
Lespedeza (Korean); from United States of America.
Leucæna glauca; from Shinyanga, Tanganyika .
Lonchocarpus eriocalyx; from Shanwa, Tanganyika.
Loudetia kagerensis; from Wembere, Tanganyika.
Loudetia simplex; from Njombe, Tanganyika.
Medicago sativa (lucerne); from South Africa.
Medicago tribuloides; from South Africa.
Medicago spp.; from the United States of America.
Meibomia discolor; from Brazil.
Melinis minutiflora (molasses grass); from Njombe, Tanganyika, and Bogota, Colombia.
Mucuna pruriens (velvet bean); from Ukiriguru, Tanganyika.
Opuntia sp. (spineless cactus); from Morogoro, Tanganyika.
Panicum antidotale; from Australia.
Panicum coloratum; from South Africa.
Panicum duestum; from Mpwapwa, Tanganyika.
Panicum maximum (Guinea grass); from Mpwapwa, Tanganyika.
Panicum meyerianum; from Mpwapwa, Tanganyika.
Panicum miliaceum; from South Africa.
Panicum repens; from Ukara, Tanganyika.
Panicum trichocladum; from Mahenge, Tanganyika, and from Uganda.
Paspalum auriculatum; from Uganda.
Paspalum commersonii; from Njombe, Tanganyika.
Paspalum dilatatum; from the United States of America.
Paspalum fimbriatum; from the United States of America.
Paspalum notatum; from the United States of America.
Paspalum uruillei; from South Africa.
Pennisetum clandestinum (Kikuyu grass); from Njombe, Tanganyika.
Pennisetum haareri; from Ukara, Tanganyika.
Pennisetum mezianum; from Shinyanga, Tanganyika.
Pennisetum polystachyon; from Mwanza, Tanganyika.
Pennisetum purpureum (elephant grass); from Mpwapwa, Tanganyika.
Pennisetum spp.; from Moshi and other centres, Tanganyika.
Pentzia incana (Karroo bush); from Singida, Tanganyika.
Phalaris tuberosa; from Kenya.
Pithecolobium saman (rain tree); from Kondoa, Tanganyika.
Prosopis chilensis (mezquit tree); from United States of America.
Prosopis juliflora (Algaroba bean); from Dar es Salaam, Tanganyika.
Peuraria hirsuta (Kudzu vine); from South Africa.
Peuraria thunbergiana (Kudzu vine); from Japan.
Rhynchelytrum roseum (red-top grass); from Uganda.
Saccharum sp.; from Uganda.
Sesbania sp.; from Mpwapwa, Tanganyika.
Setaria aurea; from Uganda.
Setaria caudula; from Mpwapwa, Tanganyika.
Setaria equatorialis; from Shinyanga, Tanganyika.
Setaria holstii; from Shinyanga, Tanganyika.
Setaria italica; from South Africa.
Setaria orthosticha; from Mpwapwa, Tanganyika.
Setaria phragmatoides; from Southern Rhodesia.
Setaria splendida (Millet grass); from Uganda.
Setaria sphacelata; from different parts of Tanganyika and South Africa.
Setaria trinerusa; from Masailand, Tanganyika.
Sorghum saccharatum; from South Africa.
Sorghum sudanense; from Nyasaland.
Sorghum versicolor; from Mpwapwa, Tanganyika.
Sorghum verticilliflorum; from Nyasaland.
Sorghum spp.; from Mpwapwa, Tanganyika.
Sporobolus glancifolius; from Mpwapwa, Tanganyika.
Sporobolus pyramidalis; from Tanganyika and Uganda.
Sporobolus spicatus; from Singida, Tanganyika.
Sporobolus spp.; from Mpwapwa, Tanganyika.
Stylosanthes Bojeri; from Mpwapwa, Tanganyika.
Stylosanthes Gayanus; from Brazil.
Stylosanthes mucronatus; from Australia.
Tamarindus indica; from Mpwapwa, Tanganyika.
Tetragonia arbuscula (Karroo bush); from Singida,
Tetragonia sp. (Karroo bush); from Singida, Tanganyika.
Tephrosia incana; from Mpwapa, Tanganyika.
Tephrosia purpurea; from Mpwapwa, Tanganyika.
Tephrosia rigida; from Babati, Tanganyika.
Themeda triandra (red oat grass); from Njombe, Tanganyika.
Trifolium polystachyum (wild clover); from Mbulu, Tanganyika.
Trifolium rueppellianum; from Mbulu, Tanganyika.
Trifolium semipilosum; from Mbulu, Tanganyika.
Trifolium umbellulatum; from Mbulu, Tanganyika.
Trifolium usambarense; from Mbulu, Tanganyika.
Trifolium spp.; from Mbulu, Tanganyika.
Urochla trichopus; from Mpwapwa, Tanganyika.
Vetiveria zizanioides (khus-khus grass); from Morogoro, Tanganyika.
Vicia sativa; from Kenya.
Vigna nilotica; from Mpwapwa, Tanganyika.
Vigna unguiculata (cow pea); from Morogoro, Tanganyika.
Vossia cuspidata; from Ukara, Tanganyika.

PAPER II

NOTES ON GRASSLAND PROBLEMS IN TANGANYIKA AND A BRIEF OUTLINE OF RESEARCH WORK IN PROGRESS

By H. J. van Rensburg

In the following article it is attempted to give a brief outline of some of the most urgent problems connected with grassland development in Tanganyika. There seems to be vast scope for rapid improvement in farming if the problems of grassland management are tackled in the right way by adopting methods which have already been proved under sound farming practice. Various aspects relative to basic principles are of great importance and it is essential that research work should be extended to cover as many aspects as possible in the field of ecology. A great amount of information is required on problems of moisture/soil/plant/animal relationships and on other aspects, for example the effect of fire on vegetation and soil under different climatic conditions.

The semi-arid regions of the Central, Northern, Western and Lake Provinces are at present the main cattle-raising areas in Tanganyika, and it is principally these that will be referred to. They are mainly comprised of deciduous thicket vegetation in most parts of the Central and Northern Provinces, of *Brachystegia/Isoberlinia* woodland in the Western Province, and the cultivation steppes in Usukuma in the Lake Province.

Aim and Object.

The principal aim and object of grassland improvement work is to determine which systems of land usage allow for the most economic use of the herbage for the production of animal products while maintaining or improving the soil fertility for subsequent crop production, depending upon the suitability of the land for cultivation. The ideal system seems to be one of rotation in which a certain proportion of the land remains under grass for a certain period the duration of which is to be determined by local conditions depending on soil, climate and other factors.

Studies on grassland form an integral part of work on animal nutrition and animal health. Our knowledge of poisonous plants in Tanganyika is very limited and this subject presents an urgent problem.

Discussion of Some of the Main Problems.

Encroachment of Thicket-forming Vegetation.—This is a very serious problem in parts of the Central and Northern Provinces where deciduous thicket vegetation occurs. Under natural conditions a certain balance seems to exist and the encroachment of woody plants is curtailed by recurrent fires. With occupation and under conditions of heavy stocking, fires are eliminated, the grass cover is destroyed, erosion sets in and bush encroachment follows. In many parts there seem to be cycles of cultivation and over-grazing until the land becomes so badly eroded that it has to be abandoned from cultivation when the development of a grass cover is prevented by further continuous grazing.

The persistent regeneration of woody plants on pastures is most troublesome and very expensive to eradicate unless the land can be cultivated or cleared sufficiently well for the herbage to be mown. Under semi-extensive conditions, it seems desirable to include a periodic fierce burn to check the development of woody plants. On some of the fields at Mpwapwa where regenerating woody growth has been consistently slashed for a period of from ten to 20 years there are still approximately 620 undesirable woody plants per acre; and if left for one or two seasons these grow up into an almost impenetrable thicket. On fields which were abandoned from native cultivation in 1928 with no subsequent clearing there was an average number of 1,723 woody plants per acre. Thorough mattocking seems to be desirable to eradicate the plants but the complete removal of some species is difficult due to the development of extensive root systems and the succulent nature of the underground portions of the plants. On suitable arable land thorough cultivation followed by grass leys seem to be the solution to the problem. The crops would compensate for the cost of clearing the land. It costs approximately Sh. 75 to Sh. 100 per acre to clear and cultivate land at Mpwapwa and a yield of about five bags of maize per acre, with prices being as high as they are at present, would pay for the cost of clearing. If, however, an equivalent amount has to be spent on clearing the land for pasture without obtaining benefit of crops the expense would be prohibitive except perhaps with more intensive farming for example dairying. It certainly cannot be considered for ranching on an economic basis.

The Difficulty of Maintaining a Desirable Vegetal Cover and the Preservation of Sufficient Shade Trees and Shelter Belts.—In most of the semi-arid areas in Tanganyika dependable water supplies are extremely limited, furthermore, there is no grazing control and large herds of livestock are moved from one place to the other in search of water and grazing. In many areas, the land in proximity to such scattered water supplies is completely devastated and under such conditions of grass mismanagement it is extremely difficult to re-establish a cover of suitable perennial pasture plants. The soil surface remains bare, hard, wind-swept and eroded and in the absence of controlled cultivation and suitable protection grass seedlings cannot establish themselves. On the whole the land has a remarkable capacity for recovery but unfortunately this has been taken for granted and damage has been irreparable. A good grass cover forms an idea protection against erosion but without such cover the soil is continuously exposed and during the long dry season with strong winds soil loss can be very serious.

Another aspect that needs to be emphasized is the desirability of leaving enough shade trees and shelter belts. In most of the livestock and mixed farming areas grassland with scattered trees and suitable shelter belts seems to be the ideal lay-out. This, however, is closely connected with the bird menace in cultivated fields and one of the reasons why many large trees are destroyed in native areas is to prevent them from forming perches or nesting sites

This is a very serious problem and one that should be tackled, but the real solution to the problem does not seem to be the destruction of useful vegetation. The elimination of excessive run-off and the provision of more watering points would help to ease the problem of re-establishing vegetation, provided that a certain amount of control can be exercised over stock numbers and their movements.

The Problem of Producing Seed of Suitable Perennial Grasses.—The production of grass seed on a commercial scale has presented great difficulty in agricultural practice in the past. Production of seed in East Africa has been limited to a few grasses only, for example, *Chloris gayana* (Rhodes grass) *Bromus marginatus*, Italian rye grass, *Sorghum*, and a few others with very limited use. The possibility of producing seed commercially from suitable able high seed-yielding species of uniform growth is an urgent problem requiring further investigation. Among other promising and desirable species seem to be *Brachiaria brizantha, Cynodon plectostachyum, Bothriochloa insculpta, Cenchrus ciliaris, Panicum maximum*, and *Setaria* spp.

Pasture Management.—The different aspects connected with grassland management are part and parcel of general land use problems. Furthermore, it seems inevitable that they will continue to crop up until the general standard of farming is raised considerably and maintained at a level well above the land exploitation methods being used at present. Drastic reform so that proper land-use methods can be employed seems the only way in which permanent improvement can be brought about. The main difficulty lies in the field where the principles of sound land husbandry are to be put across to the primitive African farmer who is living on the land. The question whether the soil can stand up to the stress and strain of abuse and neglect until he understands and can tackle it successfully is pertinent.

A Brief Outline of Research Work in Progress in Tanganyika.

Pasture research work is in progress at Mpwapwa, 65 miles east of Dodoma in the Central Province, at Tumbi, 12 miles west of Tabora in the Western Province, while a certain number of extension experiments and some co-operative work have been initiated in the Southern Highlands, Northern and Lake Provinces. Extensive experiments have been carried out in connexion with the establishment of suitable leys and for producing viable seeds of pasture grasses at Lubaga near Shinyanga and at Ukiriguru near Mwanza. Grass nurseries have been established at Iheme, the Southern Highlands Stock Farm situated near Iringa and on the Northern Province Stock Farm at Engare Nairobi. Pasture improvement work has also been initiated on the Malya Stock Farm at the headquarters of the Sukumaland Federation in the Lake Province. Periodic observations are carried out on the Msima River Stock Farm where some of the grass-burning experiments are still in progress. Co-operative experiments have been initiated on a number of farms and estates.

Mpwapwa.—Pasture work at Mpwapwa is at present mainly concentrated on gaining more information on methods to transform land which is covered by bush thicket into grassland with scattered trees. The regeneration of some of the thicket-forming species is more persistent and very troublesome while their successful eradication on an economic basis is a difficult problem. Furthermore, the maintenance and management of pasture land after the initial establishment present many difficulties which require further careful investigation. Statistical data is being collected on some aspects of this work. Some of the work on soil types, moisture conditions and vegetation communities initiated by Staples require further investigation, and should be combined with a study of the root development of different species.

In the past a number of methods have been employed to establish pasture on newly cleared fields but so far the most successful seems to be the planting of *Cynodon plectostachyum* (star grass) from roots and to allow other grasses and legumes such as *Bothriocloa insculpta, Brachiaria brizantha, Panicum maximum, Cenchrus ciliaris* and *Glycine javanica* to establish themselves amongst the Cynodon plants, thus forming a mixed pasture. This work could, however, be very much simplified if seeds of suitable species could be produced on a large scale.

Seasonal grazing and carrying capacity trials are being conducted. Experiments are in prograss in connexion with the effect of fire on deciduous thicket vegetation and observations are carried out on the relationship between pasture management and tsetse control.

Tumbi, Tabora.—Pasture investigations in connexion with grassland management have recently been initiated in the Brachystegia/Isoberlinia woodland at Tumbi about 12 miles west of Tabora. The altitude is about 4,000 feet above sea level and the average annual rainfall approximately 35 inches. The soil consists mainly of a very poor light-greyish sand derived from old granite. The vegetation consists of more or less open woodland about 30 feet high with species of Brachystegia and Isoberlinia being dominant. This woodland type is known throughout the territory as "miombo" which is also the native name for one of the Brachystegia species. Along the foothills it changes into dense vegetation which resembles the deciduous thicket of the Central Province.

The main problem is again the conversion of this woodland type into grassland with scattered trees but it is being complicated by the occurrence of the tsetse fly (*Glossina morsitans*) and by lack of adequate water supplies.

DISCUSSION ON PAPERS I AND II

Seed Supply.—One of the chief difficulties in establishing improved pastures is the fact that relatively few of the desirable indigenous grasses are good seed producers, and the high cost of planting by cutting is an obstacle. Species which are at present utilized in the form of a commercial seed supply in Kenya are Rhodes grass (*Chloris gayana*), Molasses grass (*Melinis minutiflora*) and *Bromus marginatus.* In addition to these, a number of promising indigenous grasses with good seeding qualities have been isolated, but these have not yet reached the stage of commercial seed production. There are considerable difficulties in large-scale production, chiefly connected with uneven ripening, in part due to erratic rainfall, and the absence of suitable harvesting and cleaning machinery. It was suggested that by altering the environment or by manurial treatment it might be possible to improve seeding in some species. Also, that those stoloniferous grasses which are poor seeders might be propagated by chopping and scattering, mixed in a suitable medium.

Legumes.—Trials with both indigenous and exotic legumes have been carried out in all three territories, and it was clear that the usefulness of legumes requires much further study. In areas where grasses grow well (e.g. parts of Uganda), it is possible to obtain heavy yields of nutritious grass without much difficulty, and it seems doubtful if intensive efforts to establish legumes would be worth while. Further, the tendency for leguminous plants to produce cyanogenetic glucocides must be borne in mind, since occasional deaths of cattle have been attributed to prussic acid poisoning. A study of poisonous plants should be complementary to further work on legumes.

Soil Compaction.—In some parts of East Africa the soil appears to be too compact to encourage deep rooting of grasses, even when the clay content is not particularly high. Besides hindering root growth, this prevents rapid penetration of rain, and it may be difficult to find the right method of utilization of these soils. Compaction may be a consequence of the inter-relationship between soil and climate, with the result that, after loosening, the soil will tend to revert to the compact condition.

PAPER III

RECENT PASTURE WORK IN UGANDA

By R. K. Kerkham.

A summary of pasture work in Uganda was given by me at the E.A.A.F.R.O. Conference in Nairobi in 1947. (East African Agricultural Journal, Vol. XIII, pp. 78–81.) Repetition of this summary is unnecessary, and I propose to-day to give an outline of work which has been carried out since then. It is desirable to stress once again that we in Uganda must regard pasture research as one aspect only of agronomy. We are mainly concerned with the farming systems within which animal and crop production are carried out by the same farmer: evidence continues to accumulate to confirm that the more these two sides of the farmer's activities can be linked together the better.

We need the advice of specialist officers in Uganda just as much as other parts of East Africa. Their activities should be confined very largely to the problems set out in the report of the Study Group referred to above. Most of our experimental work should be carried out at experimental farms, or experimental improvement areas, where pasture management is one amongst the other aspects of farm improvement.

Our experimental work on pastures has been carried out with the advice of the Husbandry Committee, which contains officers of both agricultural and veterinary departments. Since 1947, experiments have also been submitted to the Advisory Committee for Experimental Work of the Agricultural Department, who have been particularly concerned with design of formal experiment.

Tropical Rain Forest Zone

Work has been carried out at three main centres:—

(i) *Kawanda* which is situated in the elephant grass area.

(ii) *Entebbe Stock Farm* which is situated on poor lake-shore sands in a high rainfall area (conditions being in some way similar to Bukoba).

(iii) *Kagongo Sub-station in Kyagwa County* where soils have a low pH and carry *Cymbopogon afronardus* and *Hyparrhenia deplandra* as dominants under natural grazing conditions.

The main grass collection and preliminary grazing trials with local and introduced species has been carried out at Kawanda. Preliminary grazing trials with promising species have been carried out at all three stations. Studies of the management of elephant grass and chloris leys have been carried out at Kawanda and Entebbe. The study of cropping ratios is a major part of the work at Kawanda. At Entebbe an alternate system of husbandry has now been started replacing permanent pasture. At Kagongo improvement of pastures by cropping, re-seeding, orderly burning and chopping out undesirable species is being tried.

Extension work in these areas is mainly concerned with use of supplementary feeds for calves and cows, including cotton seed, sweet potatoes and sweet potato tops, cassava, banana and sweet potato peelings and cut elephant grass. Additional information on feeding values and rations of local foodstuffs is urgently required. Paddocking with barbed wire fences has been started by a considerable number of farmers, the main objective being reduction of herding costs.

Highland Grassland

At Kachwekano in Kigezi district work has been started on cropping ratios, and treatment of grass leys by re-seeding and fire control.

Extension work is mainly aiming at an increase in the amount of land resting under grass by resettlement of population in unoccupied country.

Scattered Tree Grassland; Combretum Hyparrhenia Area

This zone covers the main stock producing areas of Uganda with a wide range of conditions.

At Serere Experiment Station in Teso district and Ngetta Farm in Lango the main subject of study continues to be management of the grass ley, its carrying capacity and effect on maintenance of fertility.

Staff increases at Serere have made possible the start of trials designed to test the effect of ley management on the animal.

Control of thorn encroachment is being studied at Serere, and at Mulondo (Teso) and Kyoga (Lango) which are areas of low rainfall near Lake Kyoga.

The management of thin ironstone soils not suited to any considerable amount of cultivation by rotational and deferred grazing systems and fire control, is receiving some attention at Serere.

Mbarara Stock Farm fits into this zone better than any other, though rainfall is much lower than in Teso and Lango. A programme for this farm has now been made out by the Husbandry Committee which includes the use of a ley grazing system, grazing management studies and thorn control.

Extension work in these zones is being concentrated in improvement areas. There have been started only recently and activities so far have been very largely confined to getting cattle owners to take more interest in their cattle. Improvement of overgrazed areas by closure continues.

Karamoja District

Areas where work has been started lie on the borderline between the "semi desert" zone and "scattered tree grassland". Cultivation in general is confined to areas adjacent to underground water, and stock production is the main agricultural activity.

At Amudat experiments on scrub control by fire and mechanical means have been started.

At Iriri in *Themeda* and *Hyparrhenia* country, trials have been designed to determine carrying capacity should it be possible to keep cattle permanently in the area, which is now used for dry season grazing only. These trials have, however, not yet been started.

DISCUSSION ON PAPER III

Ley Grazing.—It was emphasized that in Uganda the main problem is that of ley grazing, not the establishment and maintenance of permanent pastures. With intensive cultivation under a well-distributed rainfall of over 40 inches per annum, grass leys would repay much more costly treatment than would be economic with extensive permanent pastures. For that reason the use of fertilizers could be considered seriously, and trials with these are now being carried out on several stations in Uganda. Pronounced effects have already been obtained with lime, but it is inadvisable to draw conclusions at this early stage of the work, and the results are awaited of further trials which include other fertilizers.

In the Lake Province of Tanganyika, agronomic difficulties in establishing sown grass are very much greater than in areas of higher and better distributed rainfall. There are the difficulties consequent on a fairly dense native population, a large cattle population, and in many years a long and difficult dry season. Grazing management problems and the problems of over-grazing are very considerable; to a very large extent the sociological and administrative problems overshadow the agronomic ones.

In Uganda the criteria for evaluating ley pastures are pounds of beef produced during the grazing ley period and the effect of the ley on production during the post-ley cropping period.

Supplementary Stockfeeds.—Only by-products can be considered economical supplementary feeds for stock, and in Uganda, apart from cotton seed, which is cheap, emphasis has been laid on the utilization of by-products of the farm—surplus bananas or banana skins, sweet potato peelings, etc. But in ranching areas, where beef production is the primary objective, supplementary feeds have not been found to be economical.

Fire Control.—On the extensive grassland areas of the Karamoja District of Uganda a real increase in grass has been obtained by fire control alone. An area under treatment is protected from fire for two years and then subjected to a hot burn. But no success has been obtained by burning thorn thicket in this way.

PAPER IV

GRASSLAND RESEARCH IN KENYA

By D. C. Edwards

I propose to give a brief account of the work accomplished and in progress, in order to indicate where Kenya stands at present in the matter of grassland research, and at the same time to point the direction in which I believe expansion should take place.

The general problem of improvement in the utilization of grass has been attacked on three main lines. These are:—

(*a*) Survey of the vegetation to determine the possibilities of development and classify the regions of utilization.

(*b*) The determination of correct methods of management in the main types of natural grassland.

(*c*) Provision of pasture plants for the artificial establishment of pasture in areas of suitable climatic conditions.

Survey of the Vegetation.—At the outset it became evident that no comprehensive scheme of research could be devised until the climatic regions of the country had been at least roughly defined. The range of climate extends from moist tropical and sub-tropical conditions through various intermediate stages to desert, elevation of the land in its relationship to rainfall and temperature being the main determining factor in these extreme differences of climate. This variation in the environment obviously results in an equally wide range of vegetation, but a definite grouping can be discerned and it is possible to recognize extensive plant communities which are clearly related to the various climates. The communities are, in each case, representative of a complex of climatic conditions and they provide the only available key to the regions in which we have to work. Meteorological data are of necessity inadquate in this part of the world and they would, in any case, not take us far towards analysing the complex in the present state of our knowledge. We have then, a limited number of major climatic regions demarcated by recognizable vegetation types, and within these major regions minor ones which are also reflected in the vegetation they support. If work can be carried out in a representative part of each region, it is held that the results will be applicable in large measure to the whole of the area covered by the particular plant community concerned. The first step is to survey the vegetation, recognize the communities and define the climatic regions. In Kenya, six major communities have been recognized and roughly mapped, thus providing a basis for the plan of research, but since no provision has been available specifically for survey, this knowledge has had to be gathered gradually over a considerable number of years. I should say here, for the benefit of those who are not familiar with the facilities for work in this country, that the staff engaged in grassland research has consisted until quite recently of a single research officer.

Management of the Natural Grasslands.—Forming part of the regional communities are widely differing natural grasslands, often representing a sub-climax maintained by the frequent passage of fire. These areas at present form the main basis of the stock industry, although it is apparent that as management is improved and intensified in the limited moister regions of the country the focus of the industry will shift towards the utilization of cultivated pastures, both natural and artificially established. However this may be in the future, the present requirement is to discover methods of management in accord with existing needs which will, at the same time, preserve a balance between utilization and deterioration in these extensive grassland regions. On account of relatively low moisture conditions the greater part of the country will always be dependent upon natural grassland.

The reactions of these grassland types can only be studied really effectively and correct methods of management devised by means of properly staffed regional stations. No such stations have yet become available, but an attack upon the problem has been made as far as facilities have permitted. Investigations of a more detailed character have been made at Kabete which is situated at the transitional fringe of one of the main types, and several accounts of work on the management of Kikuyu grass pasture have been published as a result of these investigations. Extension of the work to other natural pasture types has been dependent upon co-operative trials on farms in suitable localities. There is no need to stress here the defects of such an arrangement. The adventures that can befall the worker on co-operative experiments would provide amusement, had we not been so desperately dependent upon such trials for results. To mention only a few irregularities—the keener the farmer the more likely he is to spring a surprise by adding some of his own ideas to the experimental plan; many yards of fencing have disappeared in a night; and recently the East African Railways have insisted upon taking a road through our latest effort. The odd giraffe leaning over the fence and helping himself is a mere nothing in such rough work.

However, we have succeeded in some degree, and in addition to the work on Kikuyu grass pasture, we have obtained useful information upon the management of the Red Oat grass type, the dependence of the dominant (*Themeda triandra*) in this type upon periodical light burning and upon methods of suppressing the useless coarse-grass phase dominated by *Pennisetum schimperi* in the high-altitude region of farming. We are in process of determining management which will maintain the Star grass (*Cynodon*) pasture in parts of the Rift Valley, where in recent years an alarming advance of the useless *Aristida* herbage has taken place.

All this work is incomplete, and it can only be placed upon a sound footing by the provision of properly sited regional stations. It must be clearly appreciated that each main climatic area requires an investigational centre and the services of at least one trained worker.

Plants for the Artificial Establishment of Pasture.—I have dealt briefly with the position in regard to the so-called natural grasslands and I now turn to the potential agricultural areas in which most of the European and especially the African population is concentrated. Apart from the coastal belt, the development of which must await the discovery and application of means to control the tsetse fly, the possibilities of crop production are practically confined to two moist vegetation communities which I have called the "Highland Grassland and Forest" and "The Scattered Tree Grassland (Low Tree–High Grass)". The former occupies the higher land masses, roughly above 6,500 feet elevation, and the latter occurs in two main aggregates, one extending from Lake Victoria in the west to the highland mass bordering the Rift Valley, and the other from the east of Mount Kenya to the neighbourhood of Nairobi. These two vegetational regions together probably represent considerably less than one-quarter of the total area of the country, and concentrated within them is possibly some 90 per cent of the population.

It will be evident that under these circumstances the maintenance of soil fertility, and in fact of the soil itself, constitutes an urgent problem. Only if means can be devised to support the dense African population on the land can any hope of future development be discerned.

The foremost factor in the advancing deterioration is breakdown of soil structure under arable cultivation, which is closely related to capacity to absorb and retain water and to the onset of soil erosion. This breakdown appears to be especially rapid under the climatic conditions, and its effect in reducing the all-important moisture supply is very marked. The immediate necessity is to provide for a periodical soil cover in the crop rotation, and moreover a cover which will not throw the land out of use for years at a time as does the present bush fallow of shifting cultivation. It should be appreciated that the necessity is more urgent than this statement appears to imply, since the bush fallow has virtually disappeared in parts of the African lands owing to the demands of food and cash crops by an increased population, and more or less continuous crop cultivation has replaced it. The change of method towards the use of artificially established, temporary grass in the arable rotation of course implies a much closer relationship than hitherto between the animal and crop cultivation.

With a view to the provision of suitable pasture plants for this development, work has been conducted over some years, mainly at Kabete, with trials at agricultural stations in various parts of the country. Early experiments with exotic species showed that attention should be directed mainly to the indigenous flora, and here a rich field for investigation awaits us.

The chief qualities which have been sought in plants intended for temporary pasture are: (*a*) palatability, (*b*) ease of eradication when required, (*c*) good seeding properties and (*d*) ability to persist under intensive management. It has been by no means easy to find grasses which conform to all of these criteria. Most have been discarded on account of failure to satisfy the last two. A certain controversy exists as to the importance of seed-producing qualities, and it is feasible that some advance may be made in African agriculture by the use of non-seeding grasses, but the view is held that a plant which is destined to become an important factor in development must be capable eventually of providing a commercial seed supply.

The work of isolating suitable pasture plants has been conducted in the following main stages:—(1) the nursery where newly acquired material is raised and preliminary observations are made, (2) field observational plots where performance under field conditions, palatability and seeding qualities are assessed; (3) one-tenth acre seed production plots; (4) critical experiments under systems of clipping and (5) grazing trials. Concurrently with this work at Kabete, when a plant has shown promise in the earlier stages, material has been sent for trial to centres in other parts of the country. The final stage is the production of a seed supply through selected growers and release of the plant through commercial channels. This last step has been reached in the case of only three grasses which are now in fairly extensive use in the European areas. These grasses are a superior local ecotype of Rhodes grass (*Chloris gayana*), Molasses grass (*Melinis minutiflora*), and *Bromus marginatus* (of sub-tropical origin). Nzoia Rhodes grass is successful throughout the Low Tree–High Grass vegetation which is one of the two plant communities forming the agricultural region, Molasses grass succeeds in the moister part of this community and at the coast, while *Bromus* has served for the early development of ley farming in the other community, the Highland Grassland. These three species together make possible the use of sown grass in any part of the agricultural region, with the exception of the dry marginal areas, which are, in any case, probably not correctly used for arable agriculture. It is not intended to suggest, however, that the problem of providing ley grasses is solved, we have so far only touched the fringe of the possibilities in this direction. There is, for instance a very promising field for investigation of local variants or ecotypes of the common species, produced by the widely different climatic areas which occur in the country. Nzoia Rhodes grass is one of these variants which has been proved markedly more persistent under intensive management than the commercial variety previously available, and other promising ecotypes of the same species have been found. Similar possibilities apply in the case of most common grasses, and they are already being exploited in regard to Molasses grass in the work at Kabete.

In addition to the foregoing, several other species of considerable promise have reached an advanced stage in the work. Of these may be mentioned a variety of *Cenchrus ciliaris, Pennisetum stramineum, Setaria sphacelata* and *Bothriochloa insculpta.*

The search for pasture legumes has so far produced somewhat disappointing results. Although several species have given promise at first, they have usually not succeeded in competition with sown grasses, and we have not yet been able to improve upon the use of a small proportion of lucerne in the ley in areas where the plant can be grown. Apart from lucerne, no other exotic pasture legume has proved successful.

The logical advance to the grass-legume mixture is a step ahead of the stage reached in this work, but the urgent necessity to provide a means of using a temporary pasture cover in the arable rotation, it will be seen, has already been met in so far as grassland research is concerned. However, despite the recent encouraging development of ley farming in the European areas, it now becomes evident that the real crux of the problem is not the question of what grasses to use, but how to induce farmers (especially African farmers) to make use of the material available. To date, only limited progress has been made towards the necessary change of established methods; in the case of the European because of lack of intensification and the cost of bringing this about and in that of the African because of deeply rooted custom in addition to cost.

In conclusion, I would again stress, as I have on previous occasions, the necessity in future development of providing investigational centres based upon the ecological regions as defined by the major plant communities. Such centres are essential to the study of the natural grassland types and to the proper conduct of work upon artificially established pasture. The argument obviously goes further, however, for the regional investigation which is necessary to grassland research is also required in other spheres of agriculture, including both crop and animal husbandry. Whatever views may be held upon various methods of classifying agricultural development, there is no escape from the basic principle that future progress must depend upon a sound knowledge of the environment into which this development must be fitted. Otherwise, we shall follow the slow and costly path of trial and error in which past mistaken effort has been eliminated by the environment, often gradually, leaving behind formidable problems.

DISCUSSION ON PAPER IV

Exotics.—In Kenya experiments with exotic grasses have been unsuccessful in the main. In the very high altitude farming areas it is possible that exotic species might be successful, but these form a very small proportion of the farm lands of Kenya.

Kikuyu Grass.—In connexion with the difficulty of obtaining seed from indigenous grasses, mention was made of experiments in Kenya in which Kikuyu grass was passed through a silage cutter and then dropped in furrows. This method of propagation was quite successful, but in ley farming Kikuyu grass has the disadvantage that it is difficult to eradicate for the cropping period. At the dry fringe of the Kikuyu grass area ploughing twice in the dry season was found to be effective in killing most of the underground stems, but this is not true of the main region.

Crop Yields after Ley.—Attention was called to the fact that better crops are frequently obtained in the second and third years of cultivation after ley as compared with the first year. This important point warrants investigation, since no satisfactory explanation has yet been given. It is possible, however, that a wide carbon/nitrogen ratio in the soil immediately after ploughing-in grass may account for the relatively lower yields. After cultivation, the carbon/nitrogen ratio narrows owing to decomposition of fibrous plant residues, and, in the second and third crops nitrogen starvation would be less likely to limit yields.

At Ukiriguru, in the Lake Province of Tanganyika the results from post-ley cropping on relatively light soils are conflicting and on the whole disappointing, compared to the more clear-cut benefits from manuring and tie-ridging. On the heavier soils at Lubaga, in the same Province, very good grass crops can be obtained, but the ley benefit as measured in increased yields in the following crop cycle seem to be somewhat disappointing. It would seem wiser there to establish grass and then leave it down for a fair period of years, and attempt reasonable grazing restrictions.

PAPER V

HIGHLAND FERTILIZER SCHEME, KENYA

Provisional Summary of Results of Application of Fertilizers to Grass

By E. G. P. Sherwood

During 1949 the Highland Fertilizer Scheme has been carrying out a small number of experiments on grass. These experiments were designed to study the behaviour of three phosphatic fertilizers, Uganda Rock Phosphate, Soda Phosphate and Superphosphate with special reference to the time and duration of effectiveness. In this respect they failed. Observation and measurement of these experiments has provided a few results bearing on grassland research.

Technique

Each experiment consists of 27 plots, each split into two sub-plots—12 ft. × 12 ft. Recording is made by cutting and weighing green the whole produce of every plot. Cattle are excluded from the experiment.

Phosphatic fertilizers were applied at the start of the experiment only, and the effect of application in furrows against application to the surface is tested in the two halves of the split plots.

Sulphate of ammonia was applied broadcast at three rates (0, 52 and 156 lb. per acre) at the start of the experiments and after each cut.

In experiments which were sown, seed was broadcast after application of fertilizer and lightly raked in.

Phosphate Responses

Phosphates were applied at the following rates:—

Uganda Rock Phosphate	170 and 1,021 lb. per acre.
Soda Phosphate ..	170 and 510 lb. per acre.
Double Superphosphate	28 and 85 lb. per acre.

Established Grass.—No increases have been detected.

Grass from seed.—In six experiments in which germination was satisfactory, phosphate had a markedly beneficial effect in five. The experiment which did not give a marked phosphate response gave a yield of four tons of cut grass per acre after only 67 days from seeding in plots receiving no phosphate.

Weighings could be taken in only two experiments as the others suffered severely from wash, and figures would have been misleading. This did not affect the reliability of the observations which were only made on parts of plots which had been unaffected.

Nitrogen Responses.

The effect of additions of sulphate of ammonia on four established and two sown grass experiments is given in the attached table.

Each of the three average figures at the bottom of the table is made up from a total of 216 separate weighings of sub-plots. Though this is not a sufficiently large number for great reliability to be placed in the figures, they do suggest that heavier applications of the fertilizer might produce still greater increases. The response to the treble rate of application is nearly three times as large as the response to the single application.

Conclusions

Nothing more is claimed for these results than is given here. The experiments have suggested that sulphate of ammonia may be a useful fertilizer for increasing the growth of grass in Kenya as in other parts of the worlld, and that phosphatic fertilizers may greatly assist establishment of grass.

These and other results obtained in Kenya seem to run parallel to results obtained in South Africa, where quality as well as quantity is known to benefit by treatment with these two fertilizers.

SULPHATE OF AMMONIA EFFECT ON GRASSES UP TO END OF NOVEMBER, 1949

	Grass	Date sown	TONS GREEN MATERIAL PER ACRE			Date Cut
			Control Yield	Effect Sulphate of Ammonia		
				52 lb./acre	156 lb./acre	
A. Dudgeon, Rongai ..	Nzoia Rhodes	16-5-49	2·99	1·32	2·05	22-7-49
			3·08	·74	2·66	19-8-49
			·44	·07	·64	15-10-49
A. Dudgeon, Rongai ..	Local Rhodes	1947	1·11	·61	1·35	26-7-49
			1·05	·53	1·23	8-9-49
H. H. Kjaertinge, Rongai	Nzoia Rhodes	9-5-49	2·10	·04	·28	25-7-49
			3·98	·18	·22	16-8-49
			1·91	·34	·52	7-10-49
Egerton School, Njoro ..	Star	1946	·71	·19	·14	20-7-49
			2·13	·25	2·12	8-10-49
Exp'tal Station, Kitale ..	Molasses	1947	1·32	·38	1·22	10-8-49
Oldane Sapuk, Eldoret ..	Veldt	Natural	1·37	·24	·61	4-8-49
Average per cut	—	—	1·85	·41	1·09	—

PAPER VI

SUGGESTIONS RELATING TO GRASSLAND RESEARCH IN THE KENYA HIGHLANDS

By E. G. P. Sherwood

Grass is a crop which grows freely and covers large areas in Kenya. There is no doubt that by making fuller use of it and adopting methods to encourage its growth it can play a far greater part in the economy of the Colony than it does at present. The following points are concerned with the Highland areas of Kenya only.

Two factors are believed to be mainly responsible for the limited use being made of grassland: shortage of information on methods of maintaining soil fertility at a high level under grass crops; and the dormant effect of dry seasons on grass.

Soil Fertility

The importance of soil fertility and nutrient status in a soil and of studying methods of maintaining and increasing it is brought out by the following considerations:—

D. C. Edwards stresses the improvement in specific composition of feeding grasses in Kenya with increased soil fertility and regression to poorer types with falling soil fertility, particularly in high-moisture, low-temperature areas, now called "Highland Grassland". The good effects of concentrations of dung and urine can be seen in places where cattle congregate: growth is increased, the species of grass frequently improved and it is often greener during dry seasons.

There is no doubt about the benefit of dung and urine to grassland, but it is surprisingly frequently forgotten that while cattle provide an excellent means of transporting fertility they do not themselves produce it. Sale of animal products off a farm is sale of fertility and only by-products remain; dung and urine, which contain a proportion only of the total nutrients the animals have consumed. The advantage of application of nutrients to grassland direct, without necessitating depletion of other parts of a farm are obvious, and methods of doing this need study.

This applies equally to the system of grass ley rotation which, if it is to be widely used, must do two things. The grass ley must restore fertility of the soil for arable crops and also be a profitable source of income through the produce that is fed off it.

The majority of East African grassland is without legume mixture. Thus, drains on nitrogen in the soil will not be made up by nitrification in nodules. Experiments by D. C. Edwards indicate the importance of clover in a Kikuyu grass-clover mixture. In Great Britain and New Zealand reliance is placed on nitrification and nutrients are supplied to grass-clover mixtures to stimulate clovers. Elsewhere, for example in Holland, this process is not considered to be sufficient, and the importance of large quantities of nitrogenous manure is recognized.

A small number of experiments carried out by the Highland Fertilizer Scheme, in 1949, show that responses to added chemical nitrogen can be large, and that phosphate has a stimulating effect on growth from seed.

In parts of Kenya, though introduced species of grass of known quality have been established successfully, their carrying capacity has not been high, and the grasses tend to die out. This suggests the need for study into methods of raising and maintaining soil fertility to run parallel with study into varieties.

Grass is a highly palatable food for cattle, and with careful management and manuring it has been found in other parts of the world that high rates of beef and milk production can be maintained on grass alone. For example, in Holland cows giving as much as seven gallons of milk a day can be maintained during summer months on grass alone. It should be investigated whether in Kenya the same high feeding value can be produced in grass and also whether grass of sufficiently high protein content can be produced to supply part or all of the protein now supplied in concentrates to farm animals. The difficulty of growing legumes in some areas of Kenya adds point to this investigation.

In South Africa it has been shown that most types of veldt respond to added soil nutrients. The specific composition is frequently changed but not always. With suitable manuring in certain soils and climates veldt grasses, some similar to those which are found in Kenya, have been as productive as all imported grasses tried in the same soil. It is certain that vast areas of the Highlands now covered by veldt of comparatively poor quality can be greatly improved as the evidence of South Africa suggests, and that soil fertility will be a major factor in achieving this.

Establishment of grass from seed and runners is frequently unsuccessful in Kenya and it is believed that slow growth of grass and consequent competition from weeds is the principal cause of poor cover and the danger of complete failure. With high soil fertility a short period in which the soil is moist allows rapid growth of grass with a root system of considerable depth which minimizes the danger of drought.

Dormant Period of Grass Growth

The benefit of highly productive grassland is very largely lost unless methods are found of spreading the great bulk of grass which will be produced during rains, to cover dry seasons when growth comes to a standstill. In temperate regions where periods of cold impose a similar dormant period on the growth of grass, methods have been found of making peak periods of growth fill the troughs of poorer growth. This has been done mainly by discovery of methods of growing early and late flushes of grass, and extending growth into unfavourable periods, and by storage in the form of hay, dried grass and silage.

In the Highlands of Kenya the problem is allied but naturally different in detail. The need is clear for investigation in Kenya along the lines mentioned above for achieving the same success. It is true that considerable progress has been made in silage making, but as yet the possibility of using surplus grass of good quality during rains has been little explored.

Conclusion.

Emphasis has been laid on two aspects only of the problem of increasing the productive use of grass. It is held that these two lines of investigation are dependent one on the other, and on other aspects of the problem which are being investigated.

Improvement of quality and quantity of grass can be expected only when lack of soil moisture does not limit growth, which in most regions will be for part of the year only. No treatment which increases the growth during this period can be expected to prove economic unless the extra grass can be used and used profitably. Whether this can be achieved will depend very largely on whether it can be stored successfully. Similarly, investigation into grass preservation is likely to prove discouraging and fruitless unless quality and quantity can be assured.

DISCUSSION ON PAPERS V AND VI

Scorching with Sulphate of Ammonia.—The question was raised as to whether there had been any trouble with sulphate of ammonia causing scorching when applied to grass. Some scorch had been observed in an experiment where 600 lb. per acre had been applied in a single dose, but only when a short-lasting and light drizzle fell immediately after application, and even then, recovery was rapid. Experience was reported from Rothamsted Experimental Station, where dressings of over 700 lb. per acre had caused some scorching, but the effect wore off and was not reflected in the final yield.

Value of Grass Leys.—Grass leys tend to lose their value after a few years, and rotation with arable crops is necessary in order to maintain good grazing. A distinction between leys in tropical and temperate climates is that leys in temperate regions carry legumes, and thus they can be used both as a cash crop and as a means of maintaining soil fertility. In the absence of legumes it is possibly better to add chemical fertilizers in order to replace mineral plant foods which have been removed by the grazing animal and in harvests during the cropping period. It was mentioned that, in Uganda, no difference in post-ley crop yields had been found with and without grazing the ley. In the Highlands of Kenya, indigenous *Trifolium johnstoni* can be induced to form a suitable proportion of most leys by correct grazing management, and in lower agricultural areas lucerne is used as the leguminous constituent of Rhodes grass leys. The primary object of temporary leys in East Africa must be the restoration and maintenance of soil structure.

PAPER VII

THE NUTRITIVE VALUE OF EAST AFRICAN GRASS AND FODDER PLANTS

By M. H. French

Grass is a natural food for all domestic herbivora and is the only single food on which they can be maintained in health indefinitely. Consequently, for grassland investigators, it is a humbling fact that probably more of the world's animal population feeds on shrubs and trees, or on associations in which they play an important role, than on true grass or grass-legume pastures. Over large areas of East Africa, particularly the semi-arid regions, overstocking causes such deterioration in the vegetative cover that the latter fails to perform its primary function, namely conservation of the soil. Whilst the excessive pressure on these over-grazed vegetational types may be partially eased by improved management of the grazings and by a better utilization of crop residues from cultivated lands, shrub and tree associations must obviously continue important sources of fodder for low-producing indigenous stock, at least until mere numbers cease to be more important to their owners than the quality of the animals or the economic value of the hides, skins, meat or milk produced by them.

At least 75 per cent of the trees and shrubs of Africa are either browsed to some extent by domestic and wild animals or are cut or lopped for fodder purposes, but fodder trees and shrubs assume their maximum significance in areas of semi-desert scrub or similar vegetational communities, in which grass is scarce or practically non-existent for a considerable or even the greater part of the year. Fodder plants, in contrast to grass, come into leaf early in the season and before the first rains, whilst their vegetation retains its nutritive value, at a moderately high level, well into the dry season. So long as animals can obtain sufficient roughage from grass and crop residues, the leaves and pods of fodder trees and shrubs are only of supplementary value but, once grass has been eaten out, their green shoots and dead leaves may form the bulk of the ration.

On the other hand, fodder trees and shrubs should play only a subsidiary role in stock-feeding wherever grass is growing, or can be encouraged by suitable management, because they provide only a limited amount of dry season reserve fodder. Greater nutritive returns can be secured under these more intensive conditions by conserving surplus, immature and more nutritious wet-season pasturage or herbage for use later in the year.

More is known of the general composition of fodder leaves and pods than of their digestibility, nutritive values or the extent to which the digestible nutrients can be utilized by domestic animals. Generally speaking, the composition shows somewhat similar seasonal changes to those occurring in grass, but the changes are of a smaller order of magnitude, particularly for protein, minerals and fibre. In other words, in seasons of drought when grass is scarce and, what little does exist, is at its lowest ebb in protein and phosphorus, the foliage of trees and shrubs continues to be moderately well supplied with these nutrients. In fact, the foliage of such plants, because of their richness in ash constituents, can contribute largely to the mineral requirements of domestic animals. The fibre content of pods and leaves is no higher than in mature grass or hay but, unfortunately, it is usually more lignified. Such digestibility figures as are available suggest that the pods and leaves of edible trees and shrubs are equivalent in feeding value to British meadow hay, and sometimes even to lucerne hay. They are superior to East African grass or hay, grazed or harvested after periods of drought in areas of low or erratic rainfall. They cannot, however, compete with cultivated fodders, in dry matter yield over a period of years, when the management of these cultivated fodders is designed to produce sustained yields and conserve soil and water.

When confronted with extreme conditions, it is fairly easy to advise on the relative importance of fodder plants but, in intermediate zones, the problem of management is still highly controversial because of an incomplete knowledge of feeding values and of the inter-relationships between grass and fodder plants. In fact, in these intermediate zones, the only point on which there is universal agreement about the use of trees as fodder plants relates to the use of the pods and seeds of leguminous trees.

I may appear to have over-stressed the importance of fodder plants for livestock but there are available only some nine analyses of the leaves and five of the pods and seeds of East African fodder trees and shrubs, and only seven digestibility trials have been carried out. It is suggested that more information is needed if a proper use is to be made of fodder plants when improving the livestock industry in nomadic and purely pastoral areas, and especially when introducing methods for improving the nutritional level of animals in these more difficult areas.

Considering the richness of East African vegetational communities in grass genera, species and varieties, it is to be deplored that so few East African grasses have been analysed and that even fewer have had their digestibility coefficients and nutritive values determined. Chemical analysis is the quickest and easiest method of assessing nutritive value, although its usefulness is limited because it can give no indication of the percentage digested and utilized. However, it can reveal gross differences in composition and can indicate serious deficiencies.

Studies of chemical composition have shown that crude protein varies considerably between species and also with stage of maturity. In fact, the protein content is generally below the level found in temperate grasses, falls off more quickly with age and is more influenced by climatic factors.

A striking difference between East African and temperate grasses is noticed in the higher local fibre figures, even in the early stages of growth. Mineral content can vary appreciably in the same grass species when it is growing on different soils. In certain areas, there is evidence of specific mineral deficiencies, whilst on other soils, grasses show a rapid diminution of mineral matter with advancing maturity, often accompanied by a migration of phosphorus, from the foliage to the roots, as the plants dry off *in situ*.

In spite of these differences in crude composition, East African grasses show the same general trends as have been recorded in temperate regions. The nutritive value of young grass is high and, at this state of growth, the difference between genera and species is not great even for those grasses which, at maturity, show marked differences in composition. This fact follows from the decrease in protein and the increase in fibre with age. Since grass can be kept in a more nutritious state by repeated cuttings or grazings, this problem has also received attention. The results repeat the experience in temperate regions, but there is a difference between the frequency with which grasses can be cut or grazed in East Africa and in regions of higher latitude. This aspect has not received sufficient attention, nor has the allied problem of the effect of repeated cuttings on the root system and vigour of growth. Too frequent grazing or cutting reduces the vitality of the root system and grasses can be killed out. Against this must be set the fact that East African grasses grow extremely rapidly for a short period and quickly reach a fibrous, mature state. To get the best results these factors must be balanced, after making due allowance for the effects of repeated clippings on dry matter yield. Yield suffers with frequency of cutting or grazing, though the lower yield of dry matter is then more nutritious. The problem in East Africa is also complicated by variations in, and the erratic nature of, the rainfall because crude protein, ash and dry matter proportions, vary inversely and crude fibre directly with rainfall.

Increasing the interval between clippings increases dry matter yield and crude fibre content but decreases the crude protein. Whereas lime content is very little influenced by systems of clipping, phosphate varies in its response and the phosphorus content can be markedly reduced. A further complicating facttor with the larger grass species is that wilting, following drought conditions, may encourage the production of cyanogenetic glucosides which can prove fatal to animals consuming the wilted fodder.

As mentioned earlier, chemical composition alone cannot indicate the extent to which animals can digest and utilize the different grass species. This can only be determined by time-consuming digestibility trials. A number have been carried out in East Africa using sheep and cattle as experimental animals and the evidence suggests that either species can be employed, although it is usually more convenient to use the smaller animals. A point of interest, arising from such trials, is the efficiency with which local animals digest highly fibrous fodders. Because of this, the digestible organic matter and the nutritive values calculated for local grasses are higher than would be anticipated from chemical composition alone.

As would have been expected from the marked differences in vegetative habit, the feeding values of local grasses vary between species but particularly with stage of maturity.

In any discussion with farmers, one is inevitably asked what grass or grasses should be encouraged on their particular farms. From a nutritional point of view, there is a great shortage of information on this problem, and very rarely can one adequately reply to the farmer's question. In any future programme of work, considerable attention must be paid to extending the knowledge of the nutritive values of the dominant grasses in the different vegetational communities and of the variations which can be expected in these values by different systems of management. The figures to date suggest that properly managed East African grasses can have feeding values very similar to those found in temperate areas, but that grazings quickly grow away from the animals and fall in nutritive value to a level comparable with poor meadow hay in Britain. This is a very important point because, if farmers are to stock their land to the extent necessary to keep down grazings in the wet season, they would have to produce or purchase considerable quantities of supplementary foods for use in the dry season. On the other hand, if they adjust their stock to the numbers their pastures can carry in the dry season, the grass will grow right away in the wet season and quickly reach maturity and a lower nutritive value. Some middle course should obviously be followed, using an approved method for conserving the highly nutritious pasturage of the early wet season for use later in the year.

The making of hay or ensilage from grass involves time and money, and success demands some knowledge of the principles involved. As a result, European farmers in East Africa have established a wrong precedent for feeding their stock. They have found it much easier to purchase supplementary feeding stuffs from off their farms than to produce home-grown foods. This policy must be reversed, even in European areas where high producing animals are kept, if costs of animal products are to be reduced and animal husbandry placed on more sound foundations. This system most certainly must not be allowed to develop in native areas where everything possible must be done to improve the standard and economic value of animals without unduly increasing the costs of their products.

Of the foods which can be produced on farms, the ones which first suggest themselves are crop residues, roots, lucerne, etc., but the crop which is most likely to give the most economical returns, over a series of years, is grass. The traditional method of preserving grass for use later in the year is to dry it into hay. This is probably the cheapest method but is the most wasteful and probably the most uncertain because inclement weather may completely spoil the product. The principle underlying haymaking is to dry grass as quickly as possible, so that its nutrients are preserved in an undamaged form. Unfortunately, rapid drying conduces to brittleness and during subsequent collecting and transporting the more nutritious leaves can shatter and be lost. In East Africa the strong sun bleaches cut grass and destroys its vitamin A value. Much work is therefore needed to determine the best methods for making hay and whether tripods and other similar implements would allow a better quality to be made, with less loss of vitamin. If grass does not dry rapidly, a considerable amount of fermentation takes place with corresponding losses in digestible organic matter. In Britain the average loss of feeding value during haymaking amounts to 20–25 per cent which represents a considerable proportion of the value of the green crop.

It is sometimes argued that, in East Africa, grasses will dry off and be turned into hay by natural influences and that the cost of haymaking can thereby be eliminated, whilst animals can collect the dried-up herbage for themselves when they require it. Experiments have shown, however, that the feeding value of grazings allowed to mature and dry off *in situ* is much lower than if the crop had been cut and stored as hay at the correct stage of maturity. Under such conditions there is often a migration of mineral matter from the foliage to the roots, an increase in the degree of lignification, and a lowering of the general organic matter digestibility, as well as a reduction in the percentage utilization of the digested nutrients by the animal organism. To get the maximum conservation of grass nutrients in the dried form, it undoubtedly pays to cut and harvest, as this also prevents the greater wastage which results from the trampling of mature, uncut, dry forage by consuming animals.

The other method of conserving grass which is now widely practised in certain parts of the world, is to ensile the green crop either in towers, pits or clamps. By this means a succulent food is preserved for use in the dry season when the provision of succulence, as such, adds considerably to the value of the ration. Furthermore, when made under proper conditions, the losses during ensilage should not exceed 20 per cent of the feeding value. Silage, because it is made from grass cut in early stage of maturity and because it is less dependent upon weather conditions, permits the conservation of a more nutritious product than hay and one which is, or can be, rich in protein material. The feeding values of green grass and silage made from it, are approximately the same on a dry matter basis, whilst hay has lower starch equivalent and digestible protein values. The preservation of young grass in the form of a protein-rich silage is a possibility often not sufficiently well appreciated by agriculturalists and one which could do much to eliminate the need for purchasing concentrated protein foods from off the farm.

The crop used most frequently for silage in East Africa is maize, at the milky state, but not all dairy farmers wish to engage in arable projects, and maize silage will have a wider nutritive ratio than silage from young grass. Other crops which can be ensiled are green oats, barley and millet, or these crops mixed with leguminous plants such as lucerne, velvet beans, cowpeas, etc. A certain amount of work has been done on the nutritive values of silages, but further work is necessary to determine the best methods for making ensilage and the optimum stage of maturity for each crop, in order to reduce the loss of dry matter to a minimum. Similarly, there is scope in East Africa for determining the economical levels at which silage should be fed to livestock under different farming systems. More work is needed to determine the chemical changes taking place during ensilage by the different methods of preservation, including the making of molasses and A.I.V. silage. Attention should also be directed to the precautions necessary for producing different types of silage and to determine which, and to what extent, leguminous crops should either be grown with or mixed at the time of ensilage with other crops.

The most efficient method of preserving green crops for use later in the year is artificial drying. This process has not yet been studied in East Africa and is urgently in need of attention.

The economics of producing roots and tubers and of their economical use for stockfeeding purposes has been neglected, although pumpkins have been shown to be extremely valuable dry season supplements for all classes of stock.

A basic nutritional problem, which urgently needs study, is the question of succulence in dry season rations and the extent to which succulent foods can influence digestibility and the ability of animals to utilize digested nutrients, especially mineral matter. Insufficient work has been done on the affect of succulents in the nutition of young animals during the dry season and this work needs to be linked with the problem of the dry seaeson anæmia which affects so many cattle in East Africa.

It is extremely likely that the seasons of abundance and scarcity, to which East African animals are subjected, must materially influence efficiency of food conversion, and investigations are needed to determine what level of supplementary feeding during the dry season is economical and is followed by greater productive powers. The present system of feeding protein-rich concentrates during the dry season to dry rations is not necessarily the most economical system of management nor the one which should be encouraged in native areas, until further work on crop residues and home-grown foodstuffs has been carried out.

Work has been done on the feeding values of silage crops such as green lucerne, green maize, green millet, elephant grass, edible canna tops and sweet potato tops, but further investigations are needed to determine the economics of production and when the feeding of these materials will be economic.

Bound up with this should be a study of the yields and nutritive values of tubers and roots such as canna, sweet potatoes, ordinary potatoes, cassava, etc. Other home-grown foodstuffs about which more information is needed include sunflowers, groundnut tops, cowpeas, velvet beans, legume hays, millet and maize stovers, oat and barley straws. The nutritive values of these foods are known and the further work needed is to see how they can best be fitted into the economics of particular farming practices.

It was earlier stated that more work was required to determine the feeding values of the dominant grass species in the different vegetational communities of East Africa. To attempt this by laborious digestibility tests is probably the only certain way of achieving accurate results but the need for this information is so urgent that some degree of accuracy can be sacrificed in order to get an earlier assessment of values. Various formulæ have been suggested for calculating nutritive values without the need for full digestibility figures and it is suggested that preliminary surveys should be made on this basis, leaving the more detailed digestibility work for sorting out those species found promising in the preliminary survey. In this connexion, the leaf: stem ratio may be of value because it has been shown that leaf is more nutritious than stem and that any factor which encourages leafiness improves feeding values. At Mpwapwa, for instance, comparative tests were made with seven different types of star grass for which crude analyses were unsuitable for differentiating their feeding values. A study of the leaf: stem ratios at comparable stages of growth placed the varieties in the same order as was found by grazing tests. It was found that leaf colour was no indication of relative feeding value nor of protein content. Whilst it is suggested that a study of leaf: stem ratios may serve a valuable purpose for differentiating between varieties of the same grass, it is not suggested that the method can be relied upon for comparing the relative nutritive values of widely different genera, because of possible differences in the digestibilities of the stems. Specific palatability is a fundamental factor affecting selective grazing and a study of this factor is needed because, in mixed pasturage, it is necessary to do everything possible to get the less palatable species eaten in their most palatable condition so that the more attractive species may not be eaten out.

The placing of animals on plots of grass of a specified size, in order to record the number of grazing days, has attracted much attention as an easy way of determining the combined effects of yield, nutritive value, trampling and ability to withstand grazing and climatic conditions. The system so often employed in East Africa, of placing pairs of oxen on different plots until their total initial weight has been regained and recording the number of days as the carrying capacity, is subject to considerable error and should be submitted to extensive statistical study before it can be generally adopted. In fact, it is probable that equally reliable results could be obtained by more simple estimates of yield and feeding value.

During the last 30 years much has been written of mineral deficiencies in pastures and their effects on the health of domestic animals. It may, therefore, be appropriate to refer briefly to this matter.

"Nakuruitis" or "Enzootic Marasmus" has been encountered in the Rift Valley near Lakes Nakuru and Naivasha. The syndrome and species incidence of this condition closely follow findings for cobalt deficiencies in other parts of the world and the feeding of cobalt has been found to cure and prevent the symptoms. Further work to determine the cobalt content of the soils, pastures and body organs is necessary to complete the work on this deficiency. More important, however, is the need for an extension of this study to the anæmia of other high altitude volcanic areas. These high altitude anæmias are so constant a feature of East African conditions that their solution would adequately justify the costs of a properly conducted investigation.

Copper deficiencies have been reported from many parts of the world either associated with lack of cobalt, or due to a shortage of copper in the grazings or due to a conditioned shortage resulting from an excess of other minerals (molybdenum). Symptoms of copper deficiency usually include an ataxia, inanition, emaciation and a general unthriftiness. Sheep are more susceptible than cattle but both classes of stock may suffer.

No direct evidence of copper deficiency has been found in East Africa but similar symptoms are constantly encountered, i.e. the unthriftiness and stiff-gaited movements of high-grade cattle at low altitudes and the large number of lambs which appear to have weak hindquarters. Work on this possible association is urgently needed as well as on the macrocytic, hypochromic, dry season anæmia of cattle in the apparent absence of parasites. Similarly, in certain areas, animals recovering from anæmic disease such as trypanosomiasis can reach a certain level of blood rehabilitation but cannot, under dry season conditions, achieve blood normality. It was found however, that supplements of iron, copper and cobalt, fed with maintenance hay rations to such animals, allowed complete blood recovery. This work was interrupted by the war and has never been completed.

Serious phosphorus deficiency in South Africa leads to loss of appetite, emaciation, retarded growth and reproductive rates, osteoporosis and osteomalacia and even osteophagia. Certain grazings in East Africa are low in phosphorus but never to the extent of producing osteophagia. In the worst areas of Tanganyika, there is sufficient phosporus for growth but insufficient adequately to meet the needs of pregnancy and lactation.

Low percentage of sodium, potassium and chlorine have been recorded in pastures from a number of areas and the feeding of salt is necessary in these districts if animals are to remain in health and yield reasonable amounts of milk. So far as I am aware, there are no evidences of a "leeksuct" due to specific sodium or chlorine deficiency although, in the hot dry areas, there is evidence of the need to feed salt to camels to prevent skin diseases. It is also considered that although certain pastures are low in potassium, the shortage is not sufficiently acute to cause deficiency symptoms in grazing animals.

Low lime contents have been reported for pastures from different parts of East Africa but there is no evidence of a straight acalcicosis. Possibly this is partly due to the abundant sunshine, although there is evidence that the feeding of calcium to high yielding cows is advantageous. There is also a fragility in the bones of cattle and a high incidence of broken limbs and pelves in certain areas near volcanic mountains. Such pastures contain an adequate supply of lime and it is thought that there may be a shortage of calcium in the skeleton resulting from the drainage of this element from bone reserves and an interference with its absorption and storage by the high carbonate and bicarbonate alkalinity of the waters from the mountains. Metabolic studies confirm this view and indicate that carbonate alkalinity in the drinking water causes a negative calcium balance but the completion of this work was prevented by the war. A further disturbance of the skeletal reserves occurs in osteodystrophia fibrosa or "millers disease" of horses. This is usually a result of feeding large quantities of phosphorus-rich cereal by-products which disturbs the Ca:P ratio and drains the skeleton of calcium.

Deficiency of fluorine has never been reported as causing malnutrition but an excess of fluorine is well known to cause serious metabolic disturbances. The waters flowing from certain volcanic mountains of East Africa are not only very alkaline but contain appreciable quantities of fluorine. When this occurs, symptoms of fluorosis are to be found, not as a result of excessive fluorine in the grazings but because of an excess of fluorine in the drinking water coupled with the ingestion of pasturage coated with fluorine-containing dust. In the Engari-Nanyuki area, young animals are encountered with their incisors worn level with their gums. Work on this problem was stopped by the war and has not been resumed.

The metabolism of certain plants under tropical or sub-tropical conditions results in a nitrate content which is higher than usual. The ingestion of such nitrate-rich fodder by animals leads to a liberation of nitrates which can cause intra-corpuscular conversion of hæmoglobin into methæmoglobin. This is often responsible for a serious disturbance of the body metabolism which manifests itself by a photosensitization.

Over most of East Africa animals exhibit a craving for certain natural "earth-licks" and this pica has usually been interpreted as a sign that the grazings are deficient in certain essential minerals. Analytical data, from a number of these so-called "salt-licks", shows they vary in composition from almost water-insoluble soil to rich salt cakes. In fact, it is not easy to correlate the craving with any specific mineral and I consider the composition of the lick is not of great value in indicating the nature of a possible mineral deficiency and that no entirely satisfactory explanation can yet be given of the widespread East African geophagia. To assume that the beneficial effect of geophagia is due to the supply of "trace" elements which analyses have so far failed to reveal, presumes that cattle have the intelligence to seek and consume substances capable of relieving specific deficiencies. This I cannot believe because it attributes to herbivora a mental power or instinct superior to that possessed by man. The best explanation that can yet be accepted would be that, by accident, animals found and started to lick certain deposits and, because they liked the taste, continued to do so until the habit became a herd instinct encouraged by herdsmen.

DISCUSSION ON PAPER VII

High-fibre Feeds.—It was mentioned that in Uganda the cattle seem to do better on older grass than on young lush grass. It would appear that Zebu types can deal more efficiently with high-fibre feeds than European breeds do, possibly by better assimilation of the food after digestion, but no work is known which proves or disproves this. When cattle are moved to lush grazing on the shores of Lake Victoria from other parts of Uganda it takes them a full year to accustom themselves to the change of feed and to make the best use of the better grazing. It was suggested that a study of the bacterial flora of the rumen might provide valuable information on this subject.

Simple Feeding Trials.—Feeding trials with grasses and fodder plants must be carried out at or near the source of the feed, and at field stations it is seldom possible to carry out elaborate trials which can be subjected to statistical analysis. It was suggested that the central agricultural and veterinary research organizations should endeavour to find a simple technique which would enable comparable feeding trials to be carried out at field stations where grassland problems are being investigated. While the results of individual trials might not be conclusive with such a technique, it would be possible to distribute them widely in the three territories and correlation of the data should make it possible to evaluate the productivity of an area before improvement is started.

Hay and Silage.—The advisability of conserving fodder for the dry season was discussed, and experience was quoted by several members in the making of haystacks. One important point emerged, namely that termites had not been known to attack the hay itself, although they had frequently attacked the wooden supports and even the maize stalks used to provide a covering for the supporting platforms. The reason for this is not known, but it seemed clear that termites are not likely to be a limiting factor in storing hay. With regard to silage, this is of great value in dairy farming, but with ranching for beef production it would not always be economic.

PAPER VIII

APPROACH TO AN ECOLOGICAL BALANCE OF AGRICULTURE WITH SPECIAL REFERENCE TO KENYA

By D. E. Faulkner

It is only comparatively recently that a better understanding has been gained of the intimate relationship which exists between animals, climate, vegetation and soils. In many areas in Africa while animal production has increased the pastures and soils have deteriorated. This deterioration has often been caused by the disproportion existing between the high level productive potential of the animal and the comparatively low level productive capacity of the environment. It is also gradually being appreciated that deterioration of livestock manifested by poor calf crops, mediocre production, susceptibility to disease and lack of vigour is not due merely to tricks of nature but that the fundamental cause is to be found in the inability of the animal to adapt itself to its environment.

In livestock improvement it is necessary to formulate policies which will ensure that, as in the case of other branches of farming, animal husbandry conforms to a sound system of conservation farming.

The key to the development of any country's animal industry must be the study of the prevailing environmental conidtions. This is true of countries such as the United Kingdom where animal productivity has been brought to a very high level. How much more so, therefore, must this be true of Africa. Even in the United Kingdom, small though that area is, the variation in environmental conditions has led to the evolvement of many types and breeds of livestock which express their full genetic potentialities only in those parts of the country where environmental conditions are in harmony with the genetic constitution of the breed or type of livestock being utilized.

In Africa the geneticist and breeder has been apt to be carried away by the possibilities opened up as a result of Mendel's formulation of the laws of heredity. They have tended to ignore the fact that Mendel's laws are concerned only with the plant or animal's individual genetic make-up and not with its existence in a particular environment—the factor governing the full realization of that individual's genetic potentiality.

The results of livestock improvement in Africa over the past few decades have been generally disappointing because this fundamental truth has been overlooked. The study of the animal's ecological background requires far greater attention in Africa than the study of applied animal genetics and must certainly be given primary consideration when livestock improvement policies are being formulated.

In New Zealand, where conditions for animal production are exceedingly favourable, the results of a comprehensive system of dairy recording over the past forty years has shown that while substantial increases in dairy production have been secured by far the biggest single factor of improvement has been better management. An exceedingly important analysis has been made of the various factors which have led to an improvement by some 61 lb. of butterfat in the production of the average cow in New Zealand over the years 1919 to 1943. The figures given are the result of analyses of returns from thousands of herds, the average dairy herd in New Zealand being one of fifty cows although there are herds as large as nine hundred cows. Since conditions in the Highlands of Kenya have often been compared with those of New Zealand it may be of interest to record here the figures for improvement and the analysis of the factors which have led to this improvement.

In 1916–17 there were 684,032 cows in milk in New Zealand with an average fat yield of 186 lb. By 1946–47 the number of cows in milk had increased to 1,657,690 with an average butterfat production of 243 lb. In the case of recorded cows there were 107,777 cows listed in 1922–23 as being in milk for 100 days or more with an average fat yield of 234 lb. In 1946–47 these had increased to 299,311 and the fat yield to 260 lb.

The improvement achieved and demonstrated by these figures has been brought about by three principle means—

(*a*) replacements in many herds being made with Jerseys;

(*b*) selection;

(*c*) better management (mainly through improvement in the quality and utilization of pastures and feeding stuffs).

An analysis of the factors leading to the 61 lb. butterfat gain of the average cow has been made by Dr. W. Hamilton who has shown that selection from high-yielding dams was responsible for only 2 lb. of the 61 lb. (or 3.3 per cent); culling of low producers to 8 lb. (13.1 per cent); breed changes and grading up to 16 lb. (26.2 per cent); while to better management was attributed 35 lb. (57.4 per cent) of the total gain. These figures are of outstanding interest showing as they do the increase in productivity that can be achieved by an improvement in environmental conditions and this in a country where conditions, even compared with the Highlands of Kenya, might be considered unusually favourable.

Before indicating the general lines along which it is thought that livestock improvement in Kenya might safely develop it may be of interest briefly to describe the varied agricultural conditions and the principal environmental factors to be considered in planning livestock improvement in this country.

Agricultural Conditions and Method

The Arid and Semi-arid Low Altitude Areas.—Of the total area of Kenya (225,000 square miles), some 120,000 square miles, or over one-half, is occupied by a sparse pastoral African population of some 311,000 people living, under very primitive conditions, a predominantly nomadic existence and dependent on their livestock almost entirely for subsistence in an arid or semi-arid country. Part of this area closely approaches desert, the severe conditions of which are accentuated by a general lack of suitable water supplies. These people which include tribes such as the Masai and the Somali, possess, it is estimated, over one and a half million cattle, some three million sheep and goats and several hundred thousand camels. In addition to this sparsely populated area a further some 30–40,000 square miles are almost entirely unoccupied, either because desert conditions prevail, or because of the infestation of the country by the tsetse fly. All these areas are situated at relatively low altitudes, ranging from sea level up to about 4,000 feet.

The Moderate to High Rainfall, High Altitude Areas.—Lying in a comparatively small, circumscribed area, centrally situated in the country, and bordered on one side by Lake Victoria-Nyanza, and surrounding Mount Kenya on the other, are the European Settled Areas and the densely populated African Areas containing tribes such as those of the Nyanzas and the Kikuyu. In this area altitudes range from about 4,000 feet to well over 8–9,000 feet and include what must be some of the most fertile areas of Africa, endowed as they are, with high rainfall, deep fertile soils and an equitable climate.

Of this area, the European Settled Areas consist of some 10,000 square miles of beautiful and fertile country which lends itself to many types of stock farming and systems of agriculture, from extensive ranching for beef production and semi-intensive dairy ranching in the lower drier parts, to intensive mixed farming in the high rainfall, high altitude areas.

The African areas of this region also possess favourable conditions of climate and soil but the density of the population (as high as 800 persons per square mile in some parts of the Nyanza and Kikuyu areas) and the general low standard of farming at present practised, raises problems no less difficult to solve than those found in the arid and semi-arid areas of the pastoral tribes. While these areas of some 22,000 square miles have a human population of over three million, and the place of stock in the life of the tribes has become secondary to crop production, there is still a very large stock population of over one and a half million head of cattle and some three and a half million sheep and goats.

Coastal Area.—Occupied by a comparatively small human and stock population, and consisting of a relatively small area, the coastal strip is of low altitude, but with a reasonably high rainfall and soil sufficiently fertile to make this area suitable for an intensive system of agriculture. In climate this area is very similar to the densely populated areas around Lake Victoria, although the higher altitude of the basin (some 4,000 feet) ensures cooler temperatures than in the coastal strip. In this coastal strip the maintenance of livestock is a precarious and difficult undertaking owing to the heavy infestation of the area by tsetse fly and the high incidence of the tick-borne diseases.

Environmental Factors to be Considered in Animal Breeding in Kenya.

Climate.—Generally speaking, there are large areas, including both European settled areas and African areas, in which favourable conditions of altitude, rainfall and moderate temperatures make possible a high level of animal industry and crop production. These areas do not suffer from severe drought or winter conditions and the greater part of them have mean annual temperatures of less than 65° F. Even in those areas in the European settled areas where the mean annual temperature is between 65° F. and 70° F. large economic producing herds of European grade cattle are successfully maintained.

Nutrition.—Because of the favourable climatic conditions described for the European settled areas and parts of the African areas, the nutritional factor may also be considered potentially very favourable. Where cattle show the effects of a poor nutritional plane, this is because generally speaking over-stocking and over-grazing and inadequate fodder conservation has led to an insufficient quantity of foodstuffs leading to actual conditions of protein and carbohydrate deficiency. Deficiency diseases, due to lack of certain minerals, are also sometimes encountered in a few areas—Nakuruitis, for example, being caused by a deficiency of cobalt. Such conditions, however, may be easily prevented by the use of suitable licks.

Over vast areas of the low altitude, arid and semi-arid areas of the country, however, conditions are, of course, far more difficult, while other factors, such as the lack of water supplies, accentuate the effects of poor and inadequate grazing. Experience elsewhere in Africa has shown that generally speaking the imported breeds of livestock require a higher plane of nutrition than is to be found in areas such as these.

Disease.—Maintaining a constant threat to the animal industry of both the European areas and the African areas, are the many diseases found both in temperate and tropical countries, and including rinderpest, pleuro-pneumonia, foot-and-mouth disease, trypanosomiasis, anthrax and blackquarter and the tick-borne diseases such as east coast fever, heartwater and anaplasmosis and fascioliasis (liver fluke). Also, of very great importance, are the various conditions causing infertility in cattle, of which special mention must be made of infectious cervico-vaginitis in the female and epididymitis in the male. Cases of this disease are very prevalent in European grade cattle and have also been recorded in Sahiwal bulls. No case, however, has so far been reported in the indigenous stock of the country.

With regard to the tick-borne diseases, it should be mentioned that east coast fever is endemic over most of the high altitude and of the high rainfall areas and that while dipping is practised to a considerable extent in the European areas, very few dipping tanks are in operation in the African areas.

Management.—The standard of animal management in the African areas (and, in fact, of all branches of farming, except perhaps in some of the ranching areas) is very low indeed, and this, together with disease, form the limiting factors against the possession by the African of a higher-producing animal, whether it be the indigenous animal graded up to the exotic breeds, or the improved higher-producing indigenous animal.

In the European settled areas standards of management vary from below the best standards achieved in the African areas to standards as high as might be found anywhere in the world.

Balanced Farming.

There is no need to labour here the point that the future welfare and progress of Africa depends largely upon the evolvement of sound systems of permanent agriculture in which livestock will have to play a much more important part than has been the case in the past. If crop production is to be maintained at present levels, let alone be increased, the animal will have to become a vital factor in the process. Not so obvious, however, as this is the influence which the price structure of agricultural commodities may have, and in fact does have, on agricultural practice. At the present time in Kenya one of the greatest handicaps to better farming methods both in the African and European farming areas is the relatively high value of cash crops in comparison with the value of animal products. The correct relationship between animal products and the various crops, so as to stimulate the use of livestock in the farming system and, as a natural corollary, the growing and use of fodder crops for those animals, are essential if sound and stable systems of agriculture are to be practised.

Livestock Improvement Policy in Kenya.

With the above factors in mind a brief indication can now be given of the policy of livestock improvement which it is suggested might safely be applied in this Colony.

African Areas.—The policy which it is proposed should be applied generally throughout the African areas is that of the selective breeding of the local indigenous stock for those qualities desired. In certain cases where in same areas centres have progressed in the selection of tested blood lines, such lines may be utilized in other areas where conditions are similar and the stock of the same type. In other cases, such as, for example, in the Masai, where no specific type is present, cattle improvement may take the form of introducing a proven type such as the Boran, the conditions in the Masai being very suitable for this type.

It can be said that the results achieved at the Baraton Livestock Improvement and Animal Industry Centre where local Nandi stock have been selectively bred over the past 15 years has shown conclusively the value of this policy even for milk production. The Nandi cattle, which are similar to the vast bulk of the African area cattle of Kenya, have proved themselves to be vigorous and fertile, possessing the ability to give a moderate amount of milk on intensive grazing with comparatively light supplementary feeding. They are perfectly adapted to their local environmental conditions and in particular appear to be resistant to infectious cervico-vaginitis and epididymitis.

The Nandi is a small native type but as work in New Zealand has shown the small cow with the high butterfat may actually be the more paying proposition and, in the case of the Nandi Reserve, where grazing is very limited, the greater number of cows that can be grazed on a given acreage is a definite advantage. In New Zealand it was found that the large cow with a fat percentage of 3.5 per cent to 3.8 per cent produced an average butterfat yield of 240 lb. per cow from 6,472 lb. of milk. At the rate of 36.7 cows per 100 acres average production per acre was 88 lb. of butterfat and 2,383 lb. of milk. In the case of the small cow with high butterfat 5.1 per cent to 5.4 per cent (the Nandi average out at 5.9 per cent) although the milk yield is lower (5,791 lb.), the butterfat yield is some 62 lb. per cow higher. But more small cows can be grazed on the same area (43.2 per 100 acres as against 36.7 for the large breed) so that the smaller cow would appear to be the more paying proposition, since on a per acre basis she will give more butterfat (131 lb.) and more milk (2,514 lb.).

The only exception to the above policy of livestock improvement is in the case of relatively small areas where high altitudes and the low incidence of the tick-borne diseases have enabled the African peasant farmer to introduce grade cattle and to maintain them in some cases with a considerable measure of success. In such areas where the standards of farming are well above average and where the individual farm of the African is fenced, it is proposed to test the possibility of providing him with an artificial insemination service in order to protect him from the infertility conditions now so prevalent in the European areas. It is an unfortunate fact that these particular areas are not as yet served by Livestock Improvement and Animal Industry Centres such as Baraton because it is safe to say that had such centres been in existence in these areas the present demand for grade stock (which often bears a political complexion) would not have arisen. It is hoped, however, that such centres will eventually be developed and in the meantime small-scale investigations are proceeding on the introduction of Sahiwal blood (Indian Zebu) into these areas.

European Areas.—In the European areas, the importation of bulls and breeding stock of the exotic breeds from Britain, South Africa, America and Holland, etc., will undoubtedly continue and on the results so far achieved such a policy can be claimed to be justified. The difficulties confronting the dairy breeder in Kenya are immense and while in many cases the standards of management of dairy cattle are exceedingly low, it must be remembered that many of the farms on which such dairying is started, are almost completely undeveloped and that many years of hard work and much money are required before the environment can be said to have been brought up to the level of the high-grade stock maintained on those farms. The reasons why yields are low, calf mortality high, etc., are not due to the fact that the Highlands of Kenya are unsuitable for dairying with exotic breeds, but because of the undeveloped condition of the country which often accounts for the low standards of feeding and management practised. Not infrequently the grading-up of herds has been far in advance of the grading-up of the environment, with the consequence that the high-grade stock have deteriorated to the level of their environment.

In the low altitude, arid and semi-arid areas of the European areas, however, it is very possible that in the long run the best policy to follow would be the selective breeding of indigenous types for beef production. In various areas of Kenya under conditions such as these, European breeders have found from experience that the breeding of the indigenous type, the Boran, is a more economic proposition than the use of imported breeds. On one large ranch a European breeder of the Boran has, over the period 1943–1949, raised the slaughter weights of his bullocks (which he markets at five years old) from an average of 583 lb. to 699 lb., this improvement corresponding closely with the development of his farm. In the Union of South Africa European breeders have also found that the use of their indigenous breed, the Afrikander, in the hot, low rainfall areas is the soundest policy to follow.

Future Work.

As was mentioned in the first few paragraphs of this paper, the study of the ecological background and of the various environmental factors concerned must receive first consideration in any formulation of animal breeding and livestock improvement policies.

The policies which have been suggested are not based on any concrete data but only on past experience and careful observation. Very little data on which to base sound breeding programmes in an area such as East Africa are available and the following lines of work and investigation are suggested for a sounder approach to these problems:—

(*a*) The continuation of the work of disease control and the investigation of specific diseases such as infectious cervico-vaginitis and epididymitis in cattle of which little is as yet known.

(*b*) Investigation into the chemical composition and digestive nutritive values of the natural vegetation from the various ecological areas, carried out over the whole year in order to ascertain seasonal variation, together with investigation into the mineral contents of both pastures and soils in respect of their major and minor constituents. Work of this kind has already been commenced in southern Africa and elsewhere and the results have amply demonstrated the value of an approach of this kind to livestock improvement projects. Coupled with this work investigations should also be made into the methods of fodder conservation applicable to East Africa, including hay making, silage making and grass drying.

(*c*) The continuation on a wider scale of the work now being undertaken at the various livestock improvement and animal industry centres in Kenya which consists of—

(i) the study of the local native cattle of each area;

(ii) the selective breeding of the indigenous stock for the qualities desired;

(iii) the finding of animals and blood-lines of superior potentialities and once these have been found to maintain and improve them.

(*d*) The continuation on a wider scale of the immense and fundamental task of changing the African's traditional attitude to his stock and methods of farming.

(*e*) Long-term fundamental research on problems connected with the adaptation of the imported breeds to local environmental conditions.

Summary.

In general, livestock improvement in Africa has been disappointing because the genetic constitution of introduced breeds has been out of harmony with their new environmental conditions. The study and improvement of such environmental conditions is of more importance in Africa than the study of applied animal genetics.

Agricultural conditions and method and the environmental factors to be considered in animal breeding in Kenya are diverse but require study before policies of livestock improvement can be formulated.

A sound livestock improvement policy in the African areas of Kenya consists of the selective breeding of the indigenous stock. The success of such a policy for milk production has been demonstrated at Baraton and in the European settled ranching areas where pure native Boran herds are maintained for beef production.

Future work to provide essential data on which to base sound livestock improvement policies might include the following: (*a*) investigation into specific animal diseases and continuation of disease control generally; (*b*) investigation into the composition and values of the natural vegetation and into methods of fodder conservation; (*c*) continuation on a wider scale of the work now being done at the livestock improvement and animal industry centres in Kenya; (*d*) continuation of the task of changing the African's traditional attitude to his stock and methods of farming; and (*c*) long-term fundamental research on problems in connexion with the adaptation of the imported breeds to local environmental conditions.

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DISCUSSION ON PAPER VIII

Factors in Improvement of Stock.—If the environment is improved it is obvious that the productivity of the stock, either in beef or in milk, must also be raised in order to make the best use of the better environment. Thus stock breeding and agronomic research should proceed along parallel lines, but the management of pasture and stock plays as important a part as the breeding of better animals or the growing of better grasses. In ranching areas in particular, the distribution of water is probably the most important factor, since, with a poor distribution of watering places the grass is overgrazed in small areas and the cattle have to walk long distances between good grazing and water. This causes considerable wastage of energy and poor grazing management, and thus well-distributed water supplies are essential before improvements in stock and pasture can be effective. On the other hand, it may not be necessary to water cattle every day for optimum management, since experiments at Mpwapwa in Tanganyika indicated that there was no loss of condition if cattle were watered only every third day. This factor merits further study, as it is of great importance in native ranching areas.

Overstocking by poor quality animals is frequently attributed to ignorance and native tribal customs, but this cannot be altered merely by encouraging or enforcing destocking. Cattle markets must be organized, and consumer goods must be placed within easy reach of the stockowner, so that he can improve his standard of living by the sale of surplus stock. Then, and only then, will he begin to value his animals and attempt to improve stock quality and grazing management.

Extension of Mixed Farming Areas.—The question was raised as to the possibility of extending mixed farming into drier areas which are now used for ranching only. An annual rainfall of 30 inches can be taken as a rough guide to the lower limit of mixed farming, although, of course, seasonal distribution would have to be taken into account. One factor to be considered is that when a tribe expands from a moist region into a dry area, they continue to use the same methods of cultivation. Owing to the difficulty of establishing and maintaining a protective soil cover in a dry climate, serious erosion by wind and water is very liable to occur. Livestock are frequently blamed for erosion, but experience in the Teso District of Uganda has proved that by strip cropping in rotation—three years grass followed by three years cropping—an area which was formerly considered to be overstocked could carry a larger cattle population than before. However, boreholes and dams had been constructed at the start in order to disperse the cattle, and this had played a great part in the success of the scheme.

Tick Control.—In Kenya, tick control by regular dipping is considered to be essential for good stock management, but in Uganda efforts to control tick-borne diseases without dipping are showing considerable promise. By better feeding it appears that calves suffer far less mortality from these diseases, and it seems that their resistance is raised by a higher nutritional intake.

LABORATORY TRIALS WITH SOME OF THE NEWER INSECTICIDES AGAINST A SCALE INSECT (SAISSETIA SPECIES)

By **Rosemary I. Robb, Clove Research Scheme, Zanzibar**

(*Received for publication on 24th December,* 1949)

Recent research under nursery conditions on the Sudden Death disease of cloves in Zanzibar has necessitated the control of a scale insect (*Saissetia* species). Some of the better known insecticides such as D.D.T. and Gammexane proved ineffective; as a result, small-scale laboratory trials with a number of newer insecticides were carried out.

There is great difficulty in obtaining comparative information about the effectiveness of these materials, especially under tropical conditions and against tropical pests. These results, of course, apply to one insect only. But since that insect is a scale, and since scales are often of great commercial importance to tropical agriculture, and in view of the general shortage of information, it is felt that they may be of some general interest.

THE INSECT

The species was previously unknown and has now been identified as a member of the genus *Saissetia*. It is believed to be confined to Zanzibar and Pemba where it is widely distributed, infesting a range of host plants including the clove. It is found in association with the "Maji ya Moto" ant, *Oecophylla longinoda*, and unless protected by this ant is usually controlled, in the field, by Encyrtid parasites.

MATERIALS USED

1. *Pestox* (Bis (dimethylamino) phosphonus anhydride). Miscible liquid. 30 per cent toxic ingredient. Manufacturers: Pest Control, Ltd., Harston, Cambridge. Used at concentrations of 1.0 per cent, 0.5 per cent and 0.1 per cent toxic ingredient.

2. *Parathion* E 605. Miscible liquid. 25 per cent toxic ingredient. Non-oil preparation. Murphy Chemical Company, Wheathampstead, Herts. Concentrations used: 0.1 per cent, 0.05 per cent, 0.01 per cent of toxic ingredient.

3. *Fosfern* 20 E 605. Miscible liquid. 20 per cent toxic ingredient. Imperial Chemical Industries (? or Plant Protection, Ltd.). Concentrations used: 0.1 per cent, 0.05 per cent and 0.01 per cent active ingredient.

*4. *H.E.T.P.* (Hexa ethyl tetraphosphate). Miscible liquid. Murphy Chemical Co., Wheathampstead, Herts. Concentrations used: 0.1 per cent, 0.05 per cent and 0.01 per cent with the addition of sulphonated lorol at the rate of 1 gm. to 1,000 c.c. water, as spreader.

*5. *Azobenzene* 40 per cent dispersible powder. Murphy Chemical Co., Wheathampstead, Herts. Concentrations used: 1.0 per cent, 0.5 per cent and 0.1 per cent.

†6. *Rentemul.* A thiocyanate wash. Miscible liquid. Rentokil, Ltd., London, S.W.9. Concentrations used: 10 per cent, 7.5 per cent and 5 per cent.

7. *P.M.F.* (Phenyl Mercury Fixtan). Dispersible powder. Ward, Benkinsop & Co., Ltd., London. Concentrations used: 1.0 per cent, 0.5 per cent, 0.1 per cent.

LABORATORY TRIALS

1. *Method of Determining Toxicity to Active Scales*

Clove leaves and twigs were removed from the nests of *Oecophylla longinoda* bearing large and approximately equal numbers of healthy scale insects. Three leaves and one twig were treated with each concentration of an insecticide: these were dipped, allowed to dry and enclosed in covered petri dishes which were then placed in the dark to discourage movement of the insects. Untreated controls were included for each insecticide.

Inspection took place after one, two and three days: the method was as follows—the leaves from each dish were placed separately under and near to a source of electric light. The additional warmth induced activity of live scales; these were removed and counted during a period of ten minutes. It is believed that by this method a fairly accurate value of the toxicity of each insecticide was obtained.

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* H.E.T.P. and Azobenzene are primarily agaricides.

† When used in the open, Rentemul has caused some scorching of young clove leaves at these concentrations.

2. *Method of Determining Toxicity to Eggs and to Young Scales Emerging After Treatment*

The hardened chitinous skins of old scales protect the eggs and newly emerged scale nymphs. Twigs bearing a large number of these scales were collected. For every concentration of an insecticide, two or three twigs were dipped as in (1), allowed to dry and enclosed in a petri dish, with a dipped but uninfested clove leaf. Untreated controls were included for each insecticide. Visual inspection took place after one, two and three days: it was impossible to make counts.

RESULTS

The results of Trial 1 are tabulated below:—

Insecticide	*Concentration*	*Number of insects active on three consecutive days after treatment*		
PESTOX	1·0%	8	2	0
	0·5%	9	1	2
	0·1%	35	40	38
	Control	82	48	60
PARATHION	0·1%	30	7	16
	0·05%	42	24	19
	0·01%	79	41	33
	Control	73	52	42
FOSFERN 20	0·1%	20	15	8
	0·05	42	41	28
	0·01%	39	32	48
	Control	96	63	108
H.E.T.P.	0·1%	12	19	23
	0·05%	3	7	13
	0·01%	59	51	50
	Control	154	119	112
AZOBENZENE	1·0%	16	1	0
	0·5%	24	2	14
	0·1%	148	110	129
	Control	99	74	129
RENTEMUL	10·%	0	0	0
	7·5%	0	0	0
	5·0%	2	3	11
	Control	49	48	60
P. M. F.	1·0%	20	11	5
	0·5%	12	8	9
	0·1%	35	35	20
	Control	77	53	60

It will be seen that at the higher concentrations all the trial materials effected some measure of control. The most effective was Rentemul, concentrations of 10 per cent and 7.5 per cent giving complete control, and 5 per cent a good control. Pestox was effective at 1.0 per cent and 0.5 per cent and Azobenzene at 1.0 per cent.

The control of newly emerged scales and eggs determined in Trial 2 is summarized as follows:—

Rentemul.—Complete control at 10 per cent and 7.5 per cent. Very little control at 5 per cent.

Pestox.—Good control at 1.0 per cent and 0.5 per cent. Partial control at 0.01 per cent.

Fosfern 20.—Complete control at 0.1 per cent and 0.05 per cent. Partial control at 0.1 per cent.

Parathion.—Partial control at 0.1 per cent, 0.05 per cent and 0.01 per cent.

P.M.F.—No control.

H.E.T.P.—No control.

Azobenzene.—Good initial control at 1.0 per cent and 0.5 per cent. Large numbers of unaffected scales emerging later. The control is considered to be effective against eggs when no newly emerged nymphs are visible under the old scale husks three days after treatment.

CONCLUSIONS

Both Rentemul and Pestox, particularly the former, give good control of a scale insect (*Saissetia* species) under laboratory conditions. These should be worth trial in the field against other scale species. Fosfern 20 shows promise against newly emerged scales and as an ovicide; repeated applications should give good results. The remaining insecticides may not be worth applying specifically for scale control, but when used against other pests, would be of value in helping to control any scale insects that might be present.

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